POWER PLANT ENGINEERING

Established Over 35 Years

VOL. XXXV CHICAGO, MAY 15, 1931 No. 10

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Published on the 1st and 15th of each Month by the
Technical Publishing Co., 53 West Jackson Blvd., Chicago
New York Office, 171 Madison Avenue

Subscription price $2.00 a year in the United States and possessions.
Copyright 1931, by Technical Publishing Co.
Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the Act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations.

Circulation of this issue 23,650

The New Era

TIME WAS WHEN milk was milk and the production of it was left entirely up to the cow, although rumor has it that she sometimes received a little unlooked for assistance from the well.

As time went on, it was realized that in order to do good work it was necessary to have the producing unit contented. Judging from contemporary literature of this early period the cow was contented only when feeding in pastures at a considerable elevation above sea level. With data available at that time, investigations placed this elevation at 5000 ft.

Later scientific investigation proved that with proper care and feeding the elevation of the pastures was immaterial. Rapid growth of the dairy industry during this era made it necessary to pay strict attention to methods of handling, transporting and delivering milk so as to insure purity.

For years the Bowman Dairy Co. has recognized the importance of adequate inspection of dairies, methods of testing to insure the purity of the supply and sanitary facilities for bottling. Their engineers have just completed a plant which the milk industry hails as the World's Finest. It is described on the following pages.

They have gone one step farther, however, and recognizing that a contented customer is just as important a part of the business as a contented cow, they have fitted up a visitors' reception room in the new plant. This room, shown above, is the focal point of the plant and from it visitors can view practically the entire operation of receiving, pasteurizing, cooling and bottling.

BOTTLING CHICAGO'S SUPPLY OF MILK

NEW HALF MILLION-POUND RIVER FOREST PASTEURIZING AND BOTTLING PLANT OF THE BOWMAN DAIRY CO. SETS NEW STANDARD. TWO OIL-FIRED 263-B.HP. H.R.T. BOILERS AND THREE 100-T. MULTIPLE SUCTION MOTOR-DRIVEN AMMONIA COMPRESSORS INSTALLED

PASTEURIZING, BOTTLING and delivering considerably more than one million pounds of milk and cream to people in the Chicago district is the daily task of the Bowman Dairy Co. Pasteurization and bottling is carried on in five modern plants, the latest being the recently completed River Forest plant with a capacity of 500,000 lb. per day and so designed that the capacity can be increased to 750,000 lb. when desired.

Completion of this new plant closes the last of the small country bottling plants, bringing all bottling facilities within the metropolitan district close to the retail market. Milk reaches the milk plants from local districts in cans; from intermediate distances by glass-lined motor truck tanks and from considerable distances by glass-lined tank cars owned by the company. After unloading the milk is pasteurized, cooled, bottled and kept in cold storage rooms until loaded on the delivery wagons.

FIG. 1. ENGINE ROOM WITH THE SWITCHBOARD IN THE BACKGROUND

Because of the perishable nature of milk products and the importance of a pure supply to the general public, design standards are high and of a specialized nature so that the company maintains its own engineering department. This new plant designed and constructed by them is the result of cumulative experience in this line over many years and the milk industry has not been hesitant in proclaiming it the finest plant of its kind ever constructed and one which sets a new standard in the field.

Steam, refrigeration and electric power play an important part. Steam at 140 lb. pressure for pasteurizing, at 70 lb. for washing and hose racks and at 10 lb. for heating and sterilizing; refrigeration for milk cooling, cold storage and ice; electric power for ventilating fans, lights and pumps.

BUILDING ARRANGEMENT

The complete plant, of red brick with white stone trim, is shown in the headpiece with the power plant in the foreground. The power plant is a separate building separated from the main plant by a 36-ft. driveway and connected to it by a bridge and pipe tunnel as shown by the second floor plan, Fig. 3. The main building, with the tower which houses a 20,000-gal. elevated water tank, is also connected to the railway siding by a bridge which serves as a pipe tunnel for unloading the milk cars. The plant is on the main line of the Chicago & Northwestern Railroad which at this point is elevated as shown in the photograph.

On the far side of the plant, with the corner just visible under the bridge, is the well house located over a 2070-ft. deep well. The well is cased to a depth of 1315 ft. and the water, delivered at a temperature of about 60 deg. F., is comparatively soft, the total hardness running about 11 gr. per gal. It is pumped by a 300-g.p.m., 21-stage, 12-in. deepwell pump driven by a 75-hp. synchronous motor. At present the deepwell pump will deliver directly to the elevated tank but

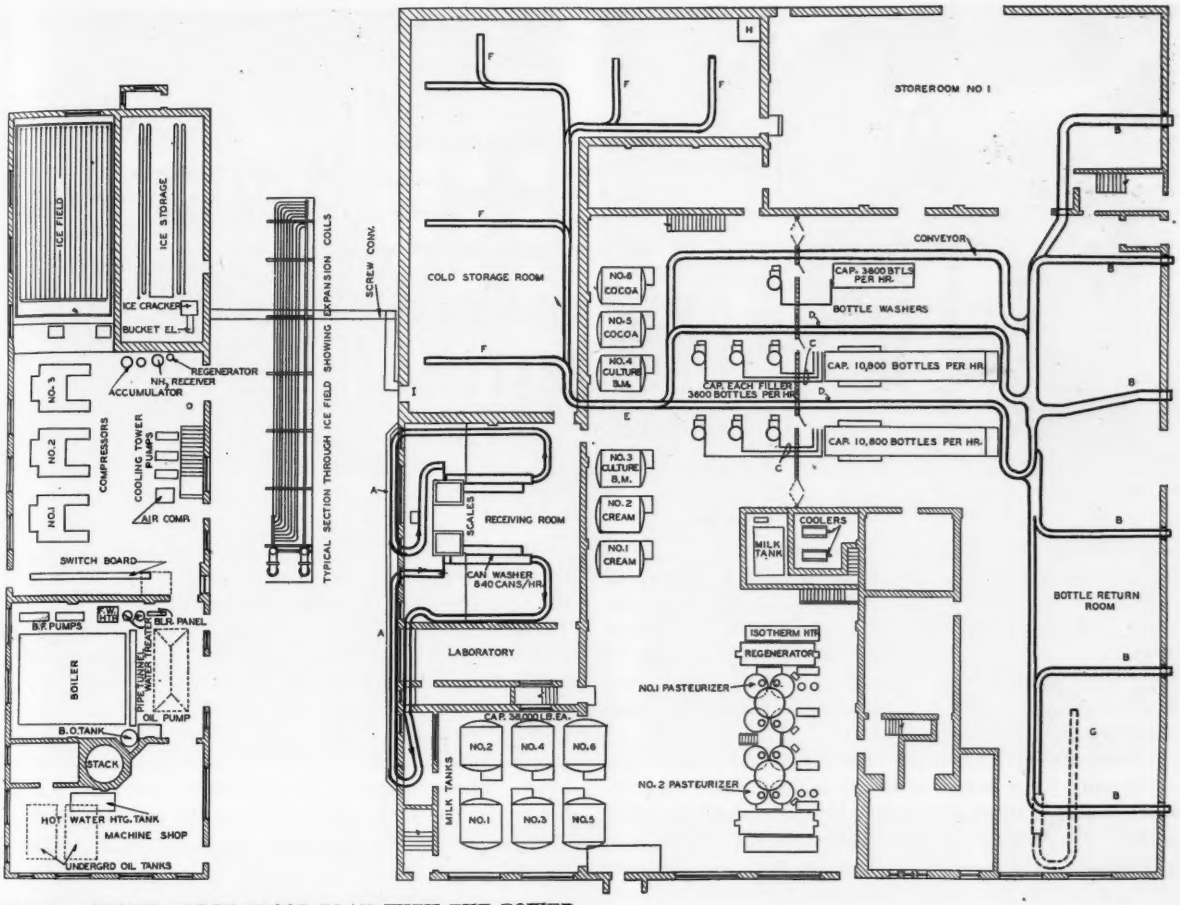

FIG. 2. (ABOVE) FIRST FLOOR PLAN WITH THE POWER PLANT ON THE LEFT

eventually a reservoir will be built. After this is done, water from the reservoir will be pumped to the storage tank by three 150-g.p.m. pumps driven by 7½-hp. totally enclosed motors. A connection with the city water supply is also available.

Plans of the first floor buildings are shown by Fig. 2. The first of the main buildings is two stories in height but the main hall with the tanks, pasteurizers and bottle fillers has a 26-ft. ceiling, leaving only the two wings available for a second floor. On the left or power plant side, the second story has an office, visitors' gallery (shown on the contents page) and the cream balcony. This part is shown in the second story plan, Fig. 3. On the other side of the main hall over the bottle return room is a storage room. Arrangement of the second story of the power plant will be discussed later.

Power Plant in a Building Separated from the Plant by a Driveway

Oil is used as boiler fuel and tank cars spotted on the siding immediately in front of the power plant are unloaded by gravity to two 12,000-gal. underground oil storage tanks. A steam connection to the siding for heating coils facilitates unloading in cold weather. The storage tanks are also fitted with heating coils. The room above the storage tanks is used as a machine shop.

Back of the machine shop is the boiler room with two 253 Erie City h.r.t. boilers with Detrick rear arches

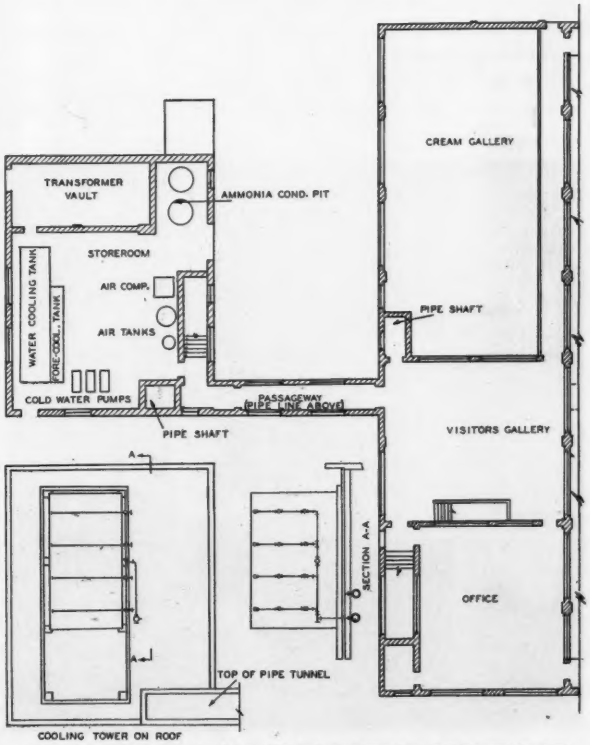

FIG. 3. SECOND FLOOR PLAN SHOWING LOCATION OF PIPE TUNNEL

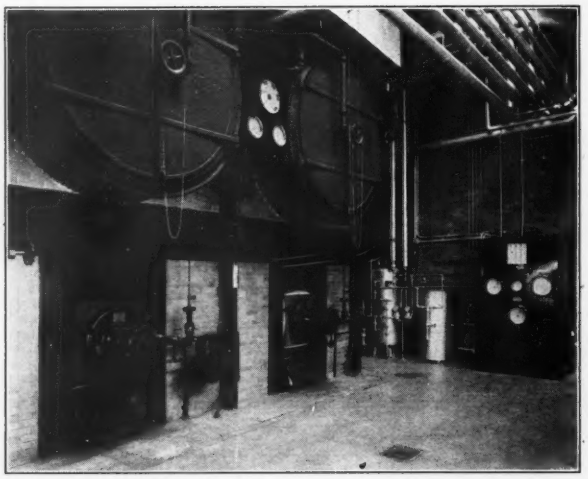

FIG. 4. FUEL OIL IS USED AS FUEL

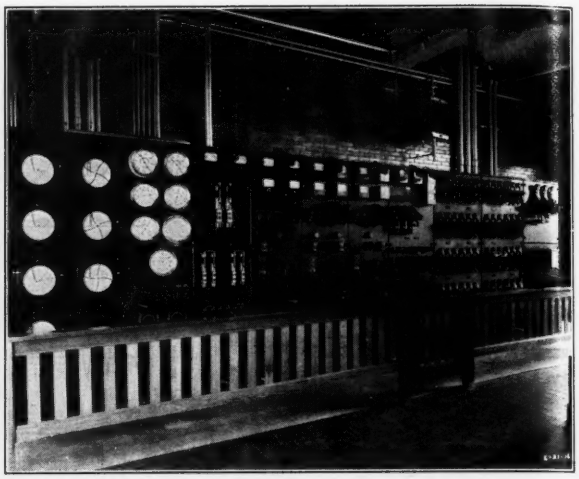

FIG. 5. THE MAIN SWITCHBOARD

and fired by Ray mechanical atomization burners. Fuel oil is delivered to the burners by two small pumps, one motor and the other steam driven, with all pipes running through a pipe tunnel in front of the boilers. Feedwater make-up is treated and deconcentrated by the Elgin system and heated in a Swartwout open heater, equipped with a vent condenser and live steam reboiling coils for deaeration.

Immediately adjacent to the boiler room and separated only by a partition is the engine room, the two-story section visible in the left foreground of the headpiece. On the main floor are the 10-panel main switchboard, three ammonia compressors, cooling tower pumps, ammonia receiver, ammonia accumulators, regenerator and noncondensable gas extractor. On the second story are the water-cooling coils, cold process water pumps and ammonia condensers. The 800-g.p.m. Burhorn cooling tower is on the roof.

Three Vilter 8 by 16-in., horizontal duplex, double-acting, multiple effect compressors rated at 100 t. and driven by 125-hp., 138-r.p.m., 230-v. unity power factor Ideal motors, supply refrigeration for the 45-t. ice field, cold storage rooms, forecooling and cooling water tanks. Three suction pressures are used; low pressure on the freezing tanks; intermediate pressure in the forecooling tank; high pressure on the water cooling tank. This cooling water at a temperature of 33—34 deg. is pumped over to the main plant by three 150-g.p.m. centrifugal pumps and is used to cool the milk in preference to brine. These pumps can be controlled from three points, the switchboard, the milk cooler or the cream balcony.

In front of the ammonia compressors is located a 152 c.f.m. at 125 lb. per sq. in. motor driven air compressor and three 375-g.p.m. motor-driven cooling tower pumps. Against the back wall are the ammonia accumulator, receiver, regenerator and noncondensable gas extractor.

At the rear of the engine room is a 45-t. per day ice field, with 324—400-lb. cans, and the ice storage room, one corner of which is shown by Fig. 6. This view shows the safety cover over the ice crusher, a feature

FIG. 6. SAFETY HOOD OVER THE ICE CRUSHER

FIG. 7. HEATING AND VENTILATING COILS AND FAN

added to protect the operator. After crushing, the ice is elevated by a bucket elevator to a screw conveyor which takes it across the driveway to the cold storage room to be used for icing milk cases.

The switchboard, Fig. 5, has, from right to left, the incoming power line panel, two power feeder panels for different sections of the plant, four synchronous motor panels, a lighting panel and two gage or control panels. These gages show the steam pressure, air pressure, cooling water temperature, ammonia head pressure, high intermediate and low suction pressures and temperatures and the discharge gas temperature from each side of the three duplex compressors. Pilot lights on the third panel from the right are on the pumps; three cooling tower pumps, three cold water pumps, ice can precooler pump and the cooling water agitator.

In the main plant, the conveyor system shown by Figs. 2 and 8 is of interest. Milk coming in on railroad tank cars is forced by compressed air through pipes across the bridge to tanks in the receiving room. Milk arriving in cans by truck is unloaded on the conveyors A-A, Fig. 2. These conveyors carry the cans into the receiving room, where the milk is dumped into automatic scales, automatically sampled for butter fat, sediment and bacteria and pumped to the milk tanks. Cans continue through the can washer where they are washed, dried and sterilized in a few minutes time and returned to the waiting truck. This conveyor and both can washers, capacity 840 cans per hour each, can be seen in Fig. 8D.

From the six 38,000-lb. tanks the milk is pumped through the pasteurizers where it is held at a temperature of 144 deg. F. for a period of at least 30 min. The main pasteurizer can be operated at 9500, 19,000, 28,500 and 38,000 lb. per hr. to take care of the filling rate of various size bottles. From the pasteurizers the milk goes to the coolers, located on a small balcony near the fillers, and then to a stainless steel container used as the supply sources for the bottle fillers. At present there are seven fillers each with a capacity of 3600 bottles per hour.

Empty bottles are received by truck, unloaded on conveyors, B, Fig. 2, and delivered to the bottle washing machines, Fig. 8A. Bottles are put through the ma-

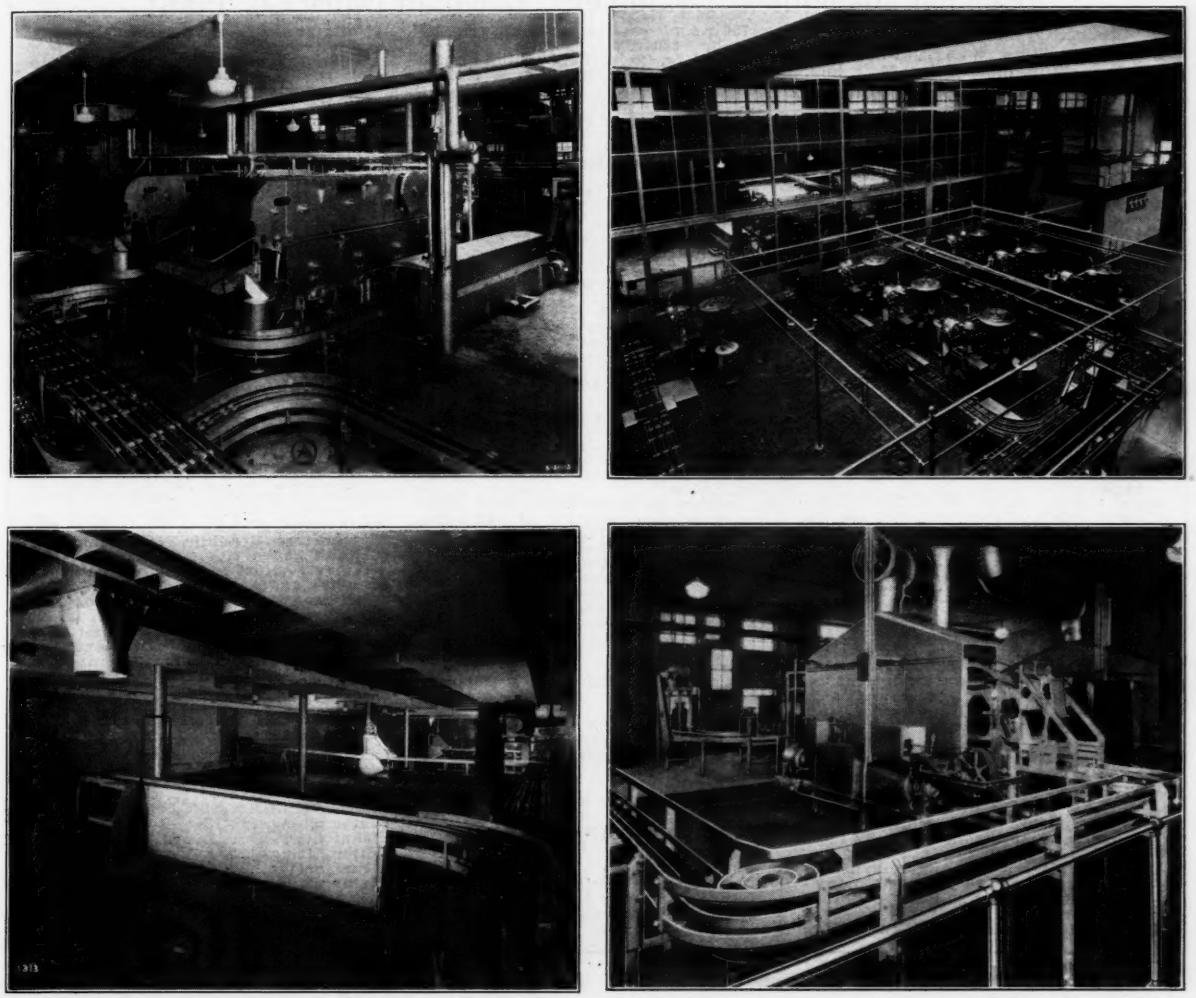

FIG. 8. THE CONVEYOR SYSTEM: A, SERVING THE BOTTLE WASHING MACHINE; B, FROM THE BOTTLE WASHERS TO THE FILLERS; C, FROM THE FILLER TO THE STORAGE ROOM AND DELIVERY TRUCKS; D, THE RECEIVING CONVEYORS AND CAN WASHER

chines where they are brushed, washed, rinsed and chlorinated and delivered from the opposite end of the machine to covered conveyors, C Fig. 2, which carry them to the filling machines, Fig. 8B, where they are filled and capped.

In the meantime, the cases continue on the conveyor, C Fig. 2, through the case washer at the side of the large machine, Fig. 8A, to the front of the fillers, ready for the filled and capped bottles. The filled cases then continue on conveyor, E Fig. 2, to the storage room, Fig. 8C. Conveyors, F Fig. 2, are used for loading wagons or vans. As can be seen from the photograph, the ends of some of these conveyors are adjustable by means of a jack, to conform to the height of the vehicle being loaded. Some of the cases are loaded direct to the delivery wagons; others are loaded on vans for distribution to loading depots serving delivery wagons for local areas. These latter cases are used with cracked ice which is delivered by the screw conveyor mentioned above through the chute shown in the foreground of Fig. 8C. Cases are iced as they pass by on the conveyor.

Bunkers for directing the air circulation in these storage rooms are visible at the top of Fig. 8C. The rooms are kept at a temperature of about 40 deg. F. and in winter are cooled by outside air. A fan on the roof blows cold air in at the corner H and it travels the length of the L shaped room leaving at I. The room is made L shaped so as to facilitate the loading of additional wagons without confusion. Conveyor G, in the lower right-hand corner of Fig. 2, operates either up or down from the ground floor to the store room above.

Principal Mechanical Equipment, Bowman Dairy Co. Plant

BOILER ROOM

2 Erie City Iron Wks., 263-hp. h.r.t. boilers, 84 in. in diameter, 20 ft. long with 3-in. tubes.
2 W. S. Ray Mfg. Co. 400-hp., 130-g.p.h. mechanical atomization oil burners driven by Westinghouse 5-hp., 220-v., 3450-r.p.m. motors.
1 American Steam Pump Co. 3 by 2 by 3-in. horizontal duplex steam pump for pumping oil.
1 W. S. Ray Mfg. Co. rotary oil pump, chain driven by a Peerless ½-hp., 220-v., 3-phase, 60-cycle, 1150-r.p.m. motor.
2 Alliance Tank Co., 12,000-gal. underground oil storage tank, 10 ft. in diameter, 20 ft. 6 in. long, complete with steam heating coils.
2 Union Steam Pump Co., 7½ by 4½ by 10-in. horizontal duplex boiler feed pumps with Hills-McCanna lubricators.
1 Swartwout Co. open feedwater heater complete with vent condenser and reboiler coils for deaeration.
1 Elgin Softener Corp. water softener and deconcentrator. Capacity 500 g.p.h. of 27 gr. per gal. water.
1 Republic Flow Meters Co. boiler panel.

Arch.....M. H. Detrick Co.
Blowoff valves...Everlasting Valve Co.
Boiler wall covering, Aertite.....Johns-Manville Corp.
Boiler setting.....H. T. Barton
Breeching .....Gillespie-Dwyer Co.
Chimney ....Consolidated Chimney Co.
Feedwater regulators, Copes.....Northern Equipment Co.
Furnace observation doors.....Furnace Economy Co.
Pump governors, Copes.....Northern Equipment Co.
Safety valves .....Consolidated Ashcroft Hancock Co., Inc.
Safety valve flange fittings.....Grinnell Co.
Stop and check valves.....Crane Co.

ENGINE ROOM

3 Vilter Mfg. Co. 8 by 16-in. horizontal duplex, double acting, multiple effect ammonia compressors driven by Ideal Electric Mfg. Co., Type SMM, 125-hp., 230-v. unity power factor, synchronous motors at 138 r.p.m. Compressors lubricated by Bowser forced feed lubricators.
4 Ideal Electric Mfg. Co., 5-kw., 125-v., 1750-r.p.m. exciter sets, driven by 7½-hp., 220-v. a.c. motors.
3 Vilter Mfg. Co. vertical shell and tube ammonia condensers with a cooling surface of 1080 sq. ft.
1 Vilter Mfg. Co. ice tank brine cooler with a surface of 3100 sq. ft.
1 E. H. Burhorn & Co. 800-g.p.m. Matola cooling tower.
1 Ideal Electric Mfg. Co., 10-panel switchboard.
1 Vilter Mfg. Co. forecooler with a cooling surface of 154 sq. ft.
2 X-L Refrigeration Co., Hilger multi-feed header, process water coolers.
2 X-L Refrigeration Co. Hilger non-freezing back valves.
3 Union Steam Pump Co., 400-g.p.m., 70-ft., head centrifugal cooling tower pumps, driven at 1760 r.p.m. by 10-hp., 220-v. Ideal motors.
3 Union Steam Pump Co. 150 g.p.m., 60 ft., head cold process water pumps driven at 1770 r.p.m. by 7½-hp. Crocker-Wheeler totally enclosed motors.
1 X L Refrigerating Co. 30 by 7 by 8-ft. cold process water cooling tank.
1 Gardner-Denver Co. 7 by 6-in., 125-lb. Type XH air compressor driven at 585 r.p.m. by an Ideal 220-v., 25-hp. motor.
1 Lammert & Mann Co. rotary compressor with capacity of 180 c.f.m. driven by an Ideal 15-hp., 220-v. motor through chain drive.
1 Cochrane Corp. Creasey ice breaker, driven by a Crocker-Wheeler 5-hp. totally enclosed motor.
1 H. W. Caldwell Co. bucket elevator and screw conveyor driven by two Crocker-Wheeler 5-hp., 220-v., totally enclosed motors.

Ice tank crane.....Euclid Crane & Hoist Co.
Ice dump.....Vilter Mfg. Co.
Ice chute .....Davidson Cold Storage Door Co.
Ammonia accumulator..Vilter Mfg. Co.
Ammonia regenerator...Vilter Mfg. Co.
Noncondensable gas extractor.....Hill Mfg. Co.
Air line separators and filters, Protectomotor.....Staynew Filter Co.
Air compressor after-cooler.....Ingersoll-Rand Co.

MISCELLANEOUS

1 Layne & Bowler Co., 300-g.p.m., 21-stage, 12-in. deepwell pump, driven at 1200 r.p.m. by a 75-hp., 220-v., Unity power factor Ideal synchronous motor.
3 Union Steam Pump Co., 150 g.p.m., 80 ft. head water works booster pumps driven by 7½-hp., 1750-r.p.m. Crocker-Wheeler totally enclosed motors.
1 National Meter Co. water meter.
1 Whitlock Coil Pipe Co. heater for wash room and tank washing.
1 Windnagel & Co., 14 ft. diameter by 20 ft. high, 20,000-gal. redwood water tank.
1 Gillespie Dwyer Co., 28,000 c.f.m. at 1 in. static pressure, heating system fan driven by a Crocker-Wheeler 10-hp., 1800-r.p.m., 220-v. motor.

Steam heating coils.....Aerofin Corp.
Air filter.....American Air Filter Co.
Unit heaters.....Modine Mfg. Co.
Cabinet heaters.....Modine Mfg. Co.
Chlorinating apparatus .....Wallace & Tiernan Co., Inc.
Ventilators, King Aeretor.....Sanitary Ventilating System, Eolus, Dickinson Co.
Stairs and gratings.....Irving Iron Works Co.
Conveyors .....Lathrop Paulson .....Mojomier Bros.
Co_2 recorder..Republic Flow Meters Co.
Draft gages.....Ellison Draft Gage Co.
Flow meters..Republic Flow Meters Co.
Oil tank gages.....Hoof Liquid Level Gage Co.
Pressure gages .....Consolidated Ashcroft Hancock Co., Inc.
Recording thermometers .....Republic Flow Meters Co. .....Taylor Instrument Cos.
Steam expansion joints.....Crane Co.
Rubber expansion joints.....U. S. Rubber Co.
Water strainers .....Self Cleaning Strainer Co.
Steam traps..Armstrong Machine Wks.
Reducing valves .....Boylston Steam Specialty Co. .....McAlear Mfg. Co.
Check valves.....Jenkins Bros.
Steam piping.....Crane Co.
Water piping.....Jas. B. Clow & Sons
Steam fittings .....Crane Co.
Water fittings .....Crane Co.
Steam valves .....Crane Co.
Water works valves....Eddy Valve Co.
Insulation .....Hubert
Insulation .....Kress
Cork insulation.....United Cork Cos.

On the cream gallery above the cold storage room and shown by Fig. 3 are the cream separator, cream and skim milk pasteurizer, coolers and grading vats. A well-equipped laboratory is provided on the ground floor adjacent to the receiving rooms.

HEATING

Heating in the power plant and some of the rooms is by unit and cabinet heaters but the main room is heated and ventilated by the filter, heater and fan equipment shown by Fig. 7. Damper regulation allows the recirculation of any desired percentage. The fan takes its suction under the cooler balcony near the No. 1 pasteurizer and discharges the warm air into the room through square openings in the ceiling. The space from which the fan takes its suction is utilized as a storage

room for clean-up apparatus, thus drying them and preventing the growth of bacteria prevalent when these tools are left damp.

At present the capacity is about 25,200 bottles per hour but the plant is so laid out that the small washer and single filler now used for odd orders can be replaced with a large machine and three fillers. Furthermore the inside wall of store room No. 1 can be moved over giving sufficient room to install a fourth 10,800 bottle per hour washer and three additional fillers to give a total capacity of 43,200 bottles per hour.

There are so many unusual features about the plant that it is impossible to do more than mention a few of the most important. Perhaps the most striking is the absence of visible piping along the walls and ceilings. All pipes are carried from the power house to and through the plant in a pipe tunnel over the bridge. Pipes are dropped vertically downward to the various machines and so kept well out of sight.

Another point of interest is the electrical wiring in underground conduits and individual panel boards cut entirely through the walls opening on both sides so that the wiring is accessible from the back.

Arrangement of the plant and glass partitions is such that practically the entire plant operation can be seen from the office. Lighting has been so well carried out that there is little difference in visibility between day and night. The main room is lit by 42—300-w. lamps set in the ceiling so as to simulate daylight; other parts of the plant are illuminated by different types of fixtures which can be seen in the various photographs.

Milk piping is, of course, a 30 per cent nickel alloy and the layout of this piping so that it is accessible for cleaning is a big problem. No ells are used, as tees are necessary so that brushes and cleaning equipment can be used. There are no screwed joints, they are all soldered so as to prevent milk seeping in and souring. All this piping is thoroughly cleaned after using and sterilized with 10-lb. steam before using again, so that wide temperature variations must be taken care of. Practically all steam piping is extra heavy. All milk tanks are washed out with warm water and then sterilized with a chlorine solution.

Details have been worked out carefully and the permanence which has been worked into the plant is discernible only after close inspection, so that perhaps the most striking feature is what an industrial engineer would call straight line production. Bottles come in the plant on one side and pass straight through, being washed, filled, cased and iced on the way, arriving at the opposite side ready to be delivered.

ACCORDING TO the report to the stockholders of the National Electric Power Co. of New York City for the fiscal year ended December 31, 1930, the operating revenue of the subsidiary companies for 1930 totaled $62,996,117, a gain of $2,762,158, or 4.6 per cent. The companies' net earnings for the year were $5,321,299, an increase of 12.4 per cent over the net earnings of the preceding year. Total electric sales for 1930 were 1,261,083,000 kw-hr., a gain of 7.9 per cent. In spite of the fact that rate reductions of over $1,000,000 were placed in effect in 1930, electric revenues were $42,990,970, a gain of 6 per cent.

Economizers as Waste Heat Recovery Apparatus

BY JOS. Y. PARCE, JR., ENG. DEVELOPMENT DEPT., ERIE CITY IRON WKS., ERIE, PA.

FUNDAMENTALLY, the addition of an economizer to a steam boiler from the standpoint of waste heat recovery is justified only when the price of fuel and the net increase in efficiency effected by the economizer are such as to provide a reasonable return on the investment necessitated by the economizer installation. Inherently, this condition requires that a considerable differential exist between the boiler exit gas temperature and the feedwater temperature and also between the boiler water temperature and the feedwater temperature. There is the possible exception to this statement where

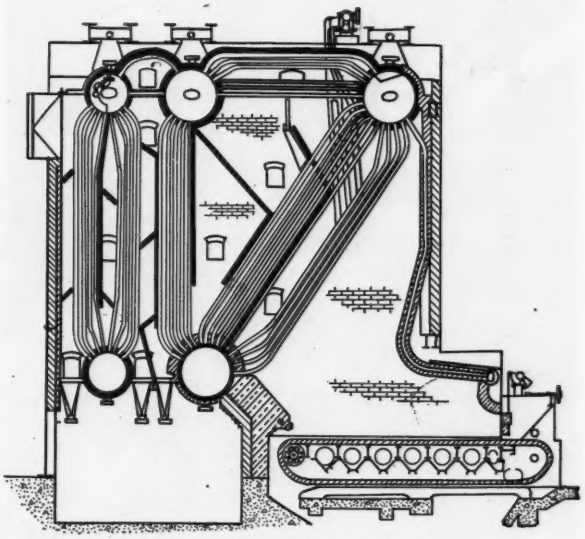

FIG. 1. INTEGRAL ECONOMIZER BAFFLED FOR COUNTER-FLOW OPERATION

the differential between boiler water and feedwater temperatures is not sufficient to take care of the energy absorbed by the economizer in the increase in the heat of the liquid of the feedwater and, therefore, a certain amount of evaporation takes place in the economizer. This condition causes what is termed a steaming economizer and requires special consideration.

There are several factors which limit the range of action of a true economizer: first, the temperature to which an economizer may heat the feedwater should be maintained somewhat below the saturation temperature corresponding to the operating pressure on the unit, otherwise evaporation may take place within the economizer, resulting in the loss of control of a positive feed of water to the boiler; second, the temperature to which an economizer may cool the flue gases should be maintained somewhat above the dew point of the gases, otherwise moisture may be deposited on the heating surface and, in combination with the sulphur compounds resulting from the sulphur in the fuel, cause corrosion of the heating surface. The draft loss incurred in an economizer is an important item in that the power and investment charges for the equipment necessary to

create this additional draft must be deducted from the gross return from the economizer when computing its net return.

Heat balance of the complete plant may indicate that feedwater may be more advantageously heated by means of exhaust steam from some part of the plant equipment or steam bled from turbine equipment. In this case, the economizer as a mechanism of waste heat recovery may be replaced or supplemented by an air heater. In any case, the particular conditions existing will govern the relative advantages to be gained by the use of an economizer and the advisability of its use. Following are two extreme examples illustrating the problem:

1. A plant having a 300-hp. boiler operating at 100 lb. steam pressure with loads ranging from 100 to 150 per cent rating obviously could not justify the use of an economizer, for the available margin in which the economizer could operate is small due to the low temperature differences and small fuel and water quantities involved.

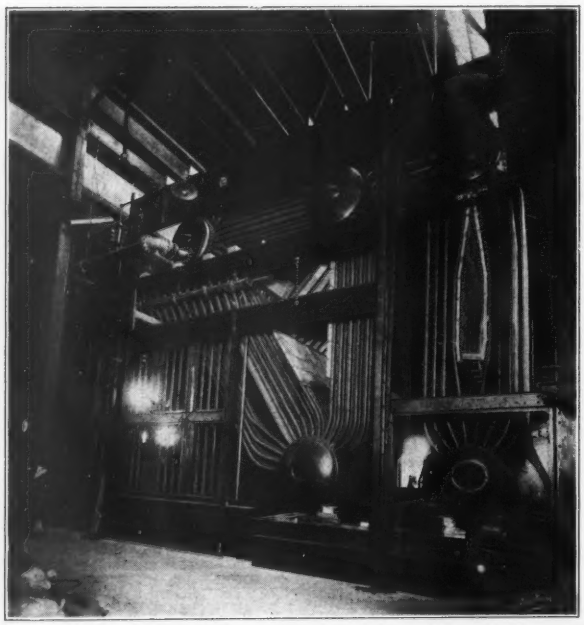

FIG. 2. A PULVERIZED COAL UNIT UNDER CONSTRUCTION

2. A plant having a 2000-hp. boiler operating at 400 lb. steam pressure with loads ranging from 400 to 500 per cent rating obviously could not omit the consideration of an economizer or at least some type of waste heat recovery apparatus.

Decreased Boiler Maintenance

Under special circumstances, the installation of an economizer may be warranted by factors other than that of waste heat recovery. Where the feedwater contains solids which are precipitated when the water is heated, it may be found advantageous to heat the water in an economizer where the water velocities are low, thus allowing a large portion of these solids to be removed from the water before it enters the boiler. Where the feedwater is considerably cooler than the boiler water, it may also be found advantageous to heat the water in an economizer in order to prevent undue local stresses being introduced in the boiler by the introduction of cold water.

Except in specially designed economizers, it is essential that the feedwater be deaerated. Otherwise, when the water is heated in the economizer, the dissolved oxygen and carbon dioxide will be deposited and induce corrosion of the steel in the tubes and drums. For special cases economizers may be made from, or coated with, materials which are not subject to corrosion by these gases.

Bent tube types of water tube boilers offer a distinct opportunity for the application of an economizer in that the integral type of economizer may be used, as shown in the illustrations. The integral type of economizer is easily arranged to provide counterflow of gases and feedwater by means of a division plate in the upper drum of the economizer, causing the cold feedwater to flow down the rear half of the tube bank to the lower drum, then up the front half of the bank back to the upper drum and into the boiler. The gas path may be similarly arranged by the use of a baffle between the front and rear halves of the economizer tube bank, making the gas flow along the same course as the feedwater but in the opposite direction. This arrangement provides the maximum mean temperature difference between gases and water, consequently the maximum heat transfer. This method of gas baffling requires the minimum of bends or turns in the gas path with the resultant reduction of draft requirements. The long, straight passes incur relatively low draft losses even with high gas velocities and turbulent flow. This arrangement makes the best use of the energy necessary to create the gas velocity and turbulence by an increase in the heat transmission coefficient.

The integral type of economizer provides a flexible design which may easily be adapted to any set of conditions. The heating surface in such an economizer may be increased or decreased either by an increase or decrease in the length of the tubes or by the use of more or less tubes in each bank and, finally, this type of economizer lends itself to small space requirements in that a relatively small increase in the length of the setting of a boiler will allow for the installation of an adequate economizer.

Bituminous Coal Sizes

Coal sizes of high volatile bituminous coal handled over the docks at the head of the Great Lakes have been standardized and are covered by regional recommendation RRI-29, issued by the Department of Commerce. The following sizes and terminology are recommended:

Block	Over a 4-in. screen
Lump	Over a 2-in. screen
Egg	Through a 4-in. and over 2 in.
Stove	Through a 2-in. and over 1¼ in.
Nut and slack	Through a 2-in. screen
Screenings	Through a 1¼-in. screen

Screen sizes refer to round-hole or square-mesh screen. Bar screens having clear openings between bars of 2⅝, 1½ and ¾ in. and slotted plate screen having clear widths of slots at the smaller end of 2⅝, 1½ and ¾ in. shall be considered equivalent to 4 in., 2 in. and 1¼-in. round-hole screen respectively.

Steam Turbines *in the* Paper Industry*

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MANY TURBINE INSTALLATIONS HAVE BEEN MADE. FLEXIBILITY AND EASE OF CONTROL ARE SUCH THAT MANY NEW APPLICATIONS WILL BE MADE. EXTRACTION TURBINES AND MULTI-GENERATOR SETS HAVE WIDE APPLICATION

PAPER MAKING is unique in many respects, not only as regards the technique of paper manufacture and the demand which the industry has created for highly specialized machinery, but also from the viewpoint of the turbine designer to whom it has opened up a field for varied turbine application far exceeding any other industry. This paper briefly recounts a number of turbine applications in paper mills, points out the feasibility of still further useful applications.

Start on a trip through an imaginary paper mill which contains typical examples of turbine applications. In the boiler room of the power house are coal feeders, boiler feed pumps, primary and induced air fans, all operated by turbines of various sizes from 10 up to 200 hp., all taking steam directly from the high-pressure boilers and exhausting into a common low pressure main from which the deaerators and often low temperature heaters take their supply of steam.

For the most part, these turbines are required to operate over a wide variation in speed. The coal feeder turbines, having adjustable wide range speed governors are probably set manually for a certain speed.

The boiler feed pump turbines are equipped with excess pressure regulators to regulate their speeds. The primary and induced draft fans are equipped with adjustable range speed governors automatically set by damper regulators or the combustion control.

In the turbine room itself are a variety of turbine applications. Outside of the main generating units which will be dealt with later there are, in the basement, small turbines for the hot well pumps, with speed governors set by the water level regulators and the circulating pump turbines also equipped with the wide speed range governors. On the turbine floor we find the dual drive exciter sets with turbine, exciter and induction motor all in line. In some instances, the turbine speed governor is set to open the turbine valves in the event of low frequency or loss of power to the induction motor while in other cases, when the exhaust steam is being supplied to feedwater heaters, pressure governors are arranged to maintain a definite back pressure at the exhaust of the turbine.

Such combined units are also frequently used to supply the light load power demand for week-ends or holidays when the main turbine unit is not required, the a.c. motor in this case being of the synchronous type instead of induction type.

Main turbine units may possibly be a simple straight condensing type used only to drive the main alternating current generator, but in a modern plant chances are they are not because one of the greatest advantages of using turbines in industrial plants is the ease with which steam may be extracted or admitted at intermediate stages at low pressures to supply the heavy demands for process steam. It is common practice to employ condensing turbines equipped with constant speed governing mechanisms and arranged for extraction of large quantities of steam at one, two or even three different pressures along the turbine shells.

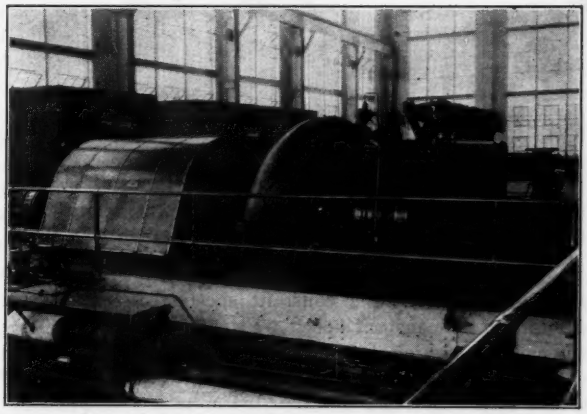


FIG. 1. ONE OF TWO 5000-KW. DOUBLE EXTRACTION CONDENSING TURBINES AT THE VISCOSE CO., MEADVILLE, PA., PLANT

A typical example might be cited: A 5000-kw., 3600-r.p.m. turbine generator set is supplied with high-pressure steam at 450 lb. gage, 750 deg. F. total temperature. It is arranged with a valve mechanism to permit extraction of say 100,000 lb. of steam at 150 lb. gage from the first stage shell; 75,000 lb. of steam at 35 lb. ga.; 10,000 lb. of steam at about 5 lb. gage for feedwater heating, and the exhaust led to a condenser at about 1 in. abs.

The 150 lb. extraction steam which is probably used

*From a paper presented before the Technical Assoc. of the Pulp & Paper Industry.

for digesters is further augmented by a supply of steam from a low-pressure boiler in which bark and other waste is normally used for fuel. At times when there is a plentiful supply of such fuel and a relatively light demand for digester steam, this boiler steam may be passed back into the turbine instead of into the process line, the control equipment on the turbine being so arranged that the demand for high pressure steam is automatically reduced as the 150 lb. low pressure steam becomes available. This transfer from maximum extraction to maximum admittance is accomplished without disturbing the speed of the unit.

Constant Speed Control at All Times

At the same time variations from zero to maximum in the amount of extracted steam at the 35 lb. stage, which is pressure controlled, may occur, without affecting the speed of the unit, this steam, of course, being used for the dryers of the main paper machines. With such a turbine, the minimum possible cost of power may be procured.

Just a word regarding the speed control of this unit.

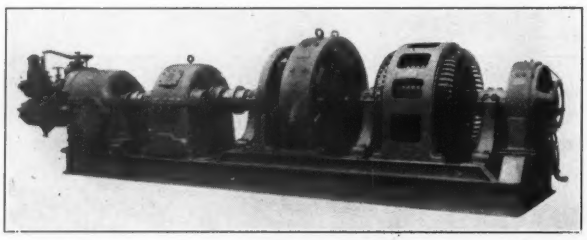


FIG. 2. SHOP VIEW OF A 700-KW. GEARED TURBINE DRIVING A 350-KW. D.C., A 315 A.C. AND A 35-KW. D.C. EXCITER

I made reference to a constant speed feature of this machine. By constant speed we mean a speed of 3600, for example, which does not deviate from 3600 by more than plus or minus one-tenth of a per cent (three and a half revolutions per minute plus or minus) no matter what the electrical load may be nor what the value of extraction at either stage might be, up to the limit of the high pressure valve gear flow.

This statement may also be applied to possible variations of boiler pressure or vacuum which, were it not for the constant speed feature, would, of course, cause the speed to vary. This important refinement in turbine speed control can be readily appreciated by those familiar with plant operation.

Leaving the main turbine room, we see how the extracted steam is being utilized: We have referred to the digester requirements for 150 lb. steam of variable quantities, but this steam is also carried over to the paper machine room, where it is used by a number of smaller turbines. These are used to drive the rolls of the main paper machines through the medium of reduction gearing. They are equipped with adjustable wide range speed governors arranged for remote adjustment of speed.

This remote adjustment is automatically accomplished by interconnection with a remotely indicating or recording paper speed tachometer located alongside the paper machine, the setting of turbine speed being handled by paper machine foreman. Extremely close speed control is, thereby, automatically obtained even though wide variations in steam pressure or exhaust pressure should occur due to the action of the thermostatically controlled make-up valves which assist, along with these small turbines, in heating the dryer rolls.

In cases where paper machines are operated by single d.c. motors, or sectional drive, instead of turbines, the speed is maintained by means of electric control devices in which the draw on the paper is adjusted by varying the voltage of the individual motors driving the different sections. This d.c. power can be obtained from turbine-driven, multi-unit sets, in which an a.c. synchronous machine is normally paralleled with the a.c. mains. The turbine is equipped with an exhaust pressure governor, the steam from this turbine being utilized to heat the dryer rolls of the paper machine. This steam is also regulated, if necessary, by moisture control devices, in which case it is unnecessary to employ auxiliary moisture control reducing valves, which take their steam from the high pressure main.

In this way, the available energy of all the steam used by the dryer rolls is utilized, surplus energy being delivered to and any deficiency taken from the a.c. system. In the event of an interruption of power to the a.c. synchronous machine, electrical controls on the turbine will immediately transfer the turbine from pressure control to speed control and will cause the speed governor which has previously been used for pre-emergency only to control the turbine speed automatically at the original synchronous speed. Results obtained from such a device have shown by many tests to have allowed of a transfer from pressure control to speed control so smoothly that the paper machine operators were not aware of the fact that the transfer had been made.

It is apparent that a large number of turbine applications have already been made in paper mills and probably more applications can be made in the future. A word of warning, however, that in order to obtain maximum plant economy and smoothness of operation very careful studies of not only the turbine control devices but also all auxiliary valve control equipment must be made in order that complete coördination of control may result.

More than one-half billion dollars will be expended in the United States during the present year in construction of 15,248 mi. of trunk pipe lines, according to estimates received by the Oklahoma Utilities Association. With many projects not yet reported it is expected that the 1931 mileage will exceed the 1930 total of 20,731 mi. Present projects include 3400 mi. of gasoline lines, 2263 mi. of crude oil lines and 9586 mi. of natural gas pipe lines. These projects include completion of three large transcontinental natural gas pipe lines passing through the Panhandle section of Oklahoma to northern and eastern markets under construction by the Northern Natural Gas Co., Missouri-Kansas Pipe Line Co. and the Continental Construction Co.; crude oil lines of the Continental Pipe Line Co. from Ponca City to Oklahoma City, the Sinclair Consolidated Oil Corp. from the east Texas field to connect with the Oklahoma City-Coffeyville, Kansas trunk lines and a gasoline line of the Phillips Pipe Line Co. from Borger, Texas to St. Louis, Mo.

Comparison of Natural Gas Fuels

PART III. COMBUSTION CHARACTERISTICS AND CALCULATIONS FOR THEORETICAL AIR REQUIREMENTS. BY PALMER B. PLACE

CALCULATIONS of the amount of air required for combustion, the amount of wet and dry gases formed and the per cent of carbon dioxide and oxygen in the gases, is readily done if the analysis of the fuel gas is known. All of this data may be plotted in a single chart for any given gas and when comparing the combustion characteristics of several gases, these charts are extremely useful.

Description is given here of the method of developing such charts for two of the ten natural gas samples selected for discussion in these articles. The analysis of the two samples is given in Table I.

TABLE I. ANALYSIS OF NATURAL GAS SAMPLES

(Per Cent by Volume)

Sample	Methane	Ethane	Carbon Dioxide	Nitrogen	Molecular Weight
No. 1	98.5	....	....	1.5	16.18
No. 8	59.1	14.5	25.1	1.3	25.21

To develop the combustion characteristics chart for any fuel, it is necessary to know the chemical equations for the oxidation of each combustible constituent of the fuel. In Table II the combustion equations for the usual combustible constituents of natural gas fuels are given.

In using chemical equations, it is well to realize that a properly balanced equation conveys a great deal of information. Thus in Table II it is seen that the relative amounts of the reacting substances, expressed either as mols, pounds, or cubic feet, are clearly defined.

TABLE II. REACTIONS FOR THE COMBUSTION OF THE CONSTITUENTS OF NATURAL GAS FUELS

1.	Methane	CH_4								
		CH_4	+	2 O_2	=	CO_2	+	2	H_2O
		1 mol	+	2 mol	=	1 mol	+	2	mol
		1 vol	+	2 vol	=	1 vol	+	2	vol
		16 lb.	+	64 lb.	=	44 lb.	+	36	lb.
		1 lb.	+	4 lb.	=	2.75 lb.	+	2.25	lb.
		1 cu. ft.	+	2 cu. ft.	=	1 cu. ft.	+	2	cu. ft.
2.	Ethane	C_2H_6								
		C_2H_6	+	3.5 O_2	=	2 CO_2	+	3	H_2O
		1 mol	+	3.5 mol	=	2 mol	+	3	mol
		1 vol	+	3.5 vol	=	2 vol	+	3	vol
		30 lb.	+	112 lb.	=	88 lb.	+	54	lb.
		1 lb.	+	3.73 lb.	=	2.93 lb.	+	1.8	lb.
		1 cu. ft.	+	3.5 cu. ft.	=	2 cu. ft.	+	3	cu. ft.
3.	Propane	C_3H_8								
		C_3H_8	+	5.0 O_2	=	3 CO_2	+	4	H_2O
		1 mol	+	5.0 mol	=	3 mol	+	4	mol
		1 vol	+	5 vol	=	3 vol	+	4	vol
		44 lb.	+	160 lb.	=	132 lb.	+	72	lb.
		1 lb.	+	3.64 lb.	=	3 lb.	+	1.64	lb.
		1 cu. ft.	+	5 cu. ft.	=	3 cu. ft.	+	4	cu. ft.
4.	Carbon	C								
		C	+	O_2	=	CO_2				
		1 mol	+	1 mol	=	1 mol				
		12 lb.	+	32 lb.	=	44 lb.				
		1 lb.	+	2.66 lb.	=	3.66 lb.				
5.	Hydrogen	H_2								
		H_2	+	.5 O_2	=	H_2O				
		1 mol	+	.5 mol	=	1 mol				
		1 vol	+	.5 vol	=	1 vol				
		2 lb.	+	16 lb.	=	18 lb.				
		1 lb.	+	8 lb.	=	9 lb.				
		1 cu. ft.	+	.5 cu. ft.	=	1 cu. ft.				

A mol is a molecular weight in pounds and as explained in a previous article, also represents 359 cu. ft. of the substance under standard conditions of temperature and pressure. Thus a mol of methane requires 2 mols of oxygen for complete combustion and yields a mol of carbon dioxide and 2 mols of water vapor. The respective weights in pounds for methane, oxygen, carbon dioxide and water are 16, 64, 44 and 36. Since a mol is also a definite volume, the equation further states that 1 volume or cu. ft. of methane requires 2 volumes or cu. ft. of oxygen to burn it to 1 volume or cu. ft. of carbon dioxide and 2 volumes or cu. ft. of water vapor.

Per cent by volume is numerically the same as per cent by mol and this fact is the key to the application of these equations to the development of the calculations for the combustion characteristics curves.

Calculations for Samples No. 1 and No. 8 are given below. Although the calculations may be based on the equations for the combustion of methane, ethane, etc., it is simpler to reduce the combustible constituents to their elements and use only the equations for the combustion of carbon and hydrogen for the calculations.

SAMPLE NO. 1. CALCULATIONS FOR THEORETICAL AIR REQUIRED FOR COMBUSTION

1. Molecular Analysis

	Per Cent by volume	Mols per Mol of Gas C	H_2	N_2	O_2
CH_4	98.5	.985	1.970	....	....
N_2	1.5	....	.....	.015	....
Total..	100.0	.985	1.970	.015	....

2. Combustion Equations

$C + O_2 = CO_2$

$.985 + .985 = .985$ Mols or vols per mol or vol of gas.

$H_2 + .5\,O_2 = H_2O$

$1.970 + .985 = 1.970$ Mols or vols per mol or vol of gas.

$1.970\,O_2 = .985\,CO_2 + 1.970\,H_2O$ Mols or vols per mol or vol of gas.

3. Air, Dry Gases and Per cent CO_2

$1.970\,O_2 = \frac{1.970}{.209} = 9.426$ Mols or vols of air per mol or vol of gas.

$9.426\ \text{Air} = (9.426)\ (.791) = 7.456$ Mols or vols of N_2 per mol or vol of gas.

$.985\,CO_2 + 7.456\,N_2 + .015\,N_2 = 8.456$ Mols or vols of dry gas per mol or vol of gas.

$\frac{.985}{8.456} = 11.65$ per cent CO_2 or $100 - 11.65 = 88.35$ per cent N_2 in the dry gases.

4. Molecular Weight of the Dry Gases

11.65 per cent of a mol of $CO_2 = .1165 \times 44 = 5.12$

88.35 per cent of a mol of $N_2 = .8835 \times 28 = 24.70$

Molecular Weight $= 29.82$

5. Weight of Dry Gases, Water Vapor, and Air per lb. of Fuel Gas.

1 mol or 16.18 lb. fuel gas yields 8.456 mols dry gases.

$\frac{8.456 \times 29.82}{16.18} = 15.60$ lb. dry gas per lb. of fuel gas.

Similarly

TABLE III. CALCULATIONS FOR THE COMBUSTION OF NATURAL GAS SAMPLE NO. 1 WITH 0 PER CENT EXCESS AIR

		Mols or Volumes per Mol or Volume of Gas					
		CH_4	C_2H_6	C_3H_8	CO_2	N_2	Total
1. Carbon in fuel gas.....	C	.985	....	....	....	....	.985
2. Hydrogen in fuel gas.....	H_2	1.970	....	....	....	....	1.970
3. Nitrogen in fuel gas.....	N_2	....	....	....	....	.015	.015
4. Oxygen in fuel gas.....	O_2	....	....	....	....	....	....
5. Oxygen req. for carbon...	O_2	.985	....	....	....	....	.985
6. Oxygen req. for hydrogen	O_2	.985	....	....	....	....	.985
7. Total oxygen required	O_2	1.970	....	....	....	....	1.970
8. Oxygen in fuel gas.....	O_2	....	....	....	....	....	....
9. Oxygen supplied by air.	O_2	1.970	....	....	....	....	1.970
10. Excess oxygen in gases	O_2	....	....	....	....	....	....
11. Total oxygen supplied	O_2	1.970	....	....	....	....	1.970
12. Total air supplied	..	9.426	....	....	....	....	9.426
13. Nitrogen from air.....	N_2	7.456	....	....	....	....	7.456
14. Nitrogen from fuel gas	N_2	....	....	....	....	.015	.015
15. Total nitrogen in gases.	N_2	7.456	....	....	....	.015	7.471
16. Carbon dioxide formed	CO_2	.985	....	....	....	....	.985
17. Total dry gases	..	8.441	....	....	....	.015	8.456
18. Water vapor formed	H_2O	1.970	....	....	....	....	1.970
19. Total wet gases	..	10.411	....	....	....	.015	10.426

TABLE IV. CALCULATIONS FOR THE COMBUSTION OF NATURAL GAS SAMPLE NO. 1 WITH 40 PER CENT EXCESS AIR

		Mols or Volumes per Mol or Volume of Gas					
		CH_4	C_2H_6	C_3H_8	CO_2	N_2	Total
1. Carbon in fuel gas.....	C	.985	....	....	....	....	.985
2. Hydrogen in fuel gas.....	H_2	1.970	....	....	....	....	1.970
3. Nitrogen in fuel gas.....	N_2	....	....	....	....	.015	.015
4. Oxygen in fuel gas.....	O_2	....	....	....	....	....	....
5. Oxygen req. for carbon...	O_2	.985	....	....	....	....	.985
6. Oxygen req. for hydrogen	O_2	.985	....	....	....	....	.985
7. Total oxygen required	O_2	1.970	....	....	....	....	1.970
8. Oxygen in fuel gas.....	O_2	....	....	....	....	....	....
9. Oxygen in required air..	O_2	1.970	....	....	....	....	1.970
10. Excess oxygen in gases	O_2	.788	....	....	....	....	.788
11. Total oxygen supplied	O_2	2.758	....	....	....	....	2.758
12. Total air supplied	..	13.196	....	....	....	....	13.196
13. Nitrogen in air supplied.	N_2	10.438	....	....	....	....	10.438
14. Nitrogen in fuel gas..	N_2	....	....	....	....	.015	.015
15. Total nitrogen in gases.	N_2	10.438	....	....	....	.015	10.453
16. Carbon dioxide formed	CO_2	.985	....	....	....	....	.985
17. Total dry gases	..	12.211	....	....	....	.015	12.226
18. Water vapor formed	H_2O	1.970	....	....	....	....	1.970
19. Total wet gases	..	14.181	....	....	....	.015	14.196

$$\frac{1.970 \times 18}{16.18} = 2.20 \text{ lb. water vapor per lb. fuel gas.}$$

$$\frac{9.426 \times 28.84}{16.18} = 16.80 \text{ lb. air required per lb. fuel gas.}$$

Thus, for complete combustion, 1 lb. of Sample No. 1 requires 16.80 lb. of air to burn it to 15.60 lb. of dry gases and 2.20 lb. of water vapor with a resulting CO_2 content in the dry gases of 11.65 per cent. Similarly, 1 cu. ft. of Sample No. 1 requires 9.426 cu. ft. of air to burn it to 8.456 cu. ft. of dry gases and 1.97 cu. ft. of water vapor. (All volumes at standard conditions of 32 deg. F. and 14.7 lb.)

Calculations for Various Amounts of Excess Air

To calculate the above-mentioned characteristics for different amounts of excess air it is only necessary to find the amount of air supplied and correct the amount of dry gases for the excess air.

Calculations for 40 Per Cent Excess Air.

1. Air Supplied.

$1.970\ O_2 \times .40 = .788$ Mols excess oxygen.

$$\frac{.788}{.209} = 3.77 \text{ Mols excess air or } 3.77 \times .791 = 2.98 \text{ Mols excess } N_2$$

$9.426 + 3.770 = 13.196$ Mols total air supplied.

TABLE V. COMBUSTION CHARACTERISTICS OF FUEL GAS SAMPLE NO. 1

Excess Air— Per cent by wt.	0	20	40	60	80	100
Fuel gas—lb.	1.00	1.00	1.00	1.00	1.00	1.00
Air—lb. per lb. fuel gas	16.80	20.16	23.52	26.88	30.24	33.60
Dry gases—lb. per lb. fuel gas	15.60	18.97	22.32	25.68	29.04	32.40
Water vapor—lb. per lb. fuel gas	2.20	2.20	2.20	2.20	2.20	2.20
Wet gases—lb. per lb. fuel gas	17.80	21.16	24.52	27.88	31.24	34.60
CO_2 in gases—per cent by vol.	11.65	9.53	8.05	6.99	6.17	5.51
O_2 in gases—per cent by vol.	0.0	3.81	6.44	8.38	9.86	11.02
Molecular wt. of dry gases	29.82	29.68	29.54	29.45	29.36	29.29
Fuel gas—cu. ft. (32° F. and 14.7 lb.).....	1.00	1.00	1.00	1.00	1.00	1.00
Air—cu. ft. per cu. ft. gas	9.43	11.39	13.20	15.07	16.95	18.84
Dry gases—cu. ft. per cu. ft. gas.....	8.46	10.34	12.23	14.10	15.98	17.87
Water vapor—cu. ft. per cu. ft. gas.....	1.97	1.97	1.97	1.97	1.97	1.97
Wet gases—cu. ft. per cu. ft. gas.....	10.43	12.32	14.20	16.07	17.95	19.84
Density of dry gases—lb. per cu. ft.....	.0831	.0827	.0823	.0820	.0818	.0816

TABLE VI. CALCULATION FOR THE COMBUSTION OF NATURAL GAS SAMPLE NO. 8 WITH 0 PER CENT EXCESS AIR

		Mols or Volumes per Mol or Volume of Gas					
		CH_4	C_2H_6	C_3H_8	CO_2	N_2	Total
1. Carbon in fuel gas.....	C	.591	.290	....	.251	....	1.132
2. Hydrogen in fuel gas.....	H_2	1.182	.435	....	....	....	1.617
3. Nitrogen in fuel gas.....	N_2	....	....	....	....	.013	.013
4. Oxygen in fuel gas.....	O_2	....	....	....	.251	....	.251
5. Oxygen req. for carbon...	O_2	.591	.290	....	.251	....	1.132
6. Oxygen req. for hydrogen	O_2	.591	.218	....	....	....	.809
7. Total oxygen required	O_2	1.182	.508	....	.251	....	1.941
8. Oxygen in fuel gas.....	O_2	....	....	....	.251	....	.251
9. Oxygen in required air..	O_2	1.182	.508	....	....	....	1.690
10. Excess oxygen in gases	O_2	....	....	....	....	....	....
11. Total oxygen supplied	O_2	1.182	.508	....	....	....	1.690
12. Total air supplied	..	5.655	2.431	....	....	....	8.086
13. Nitrogen in air supply...	N_2	4.473	1.923	....	....	....	6.396
14. Nitrogen in fuel gas..	N_2	....	....	....	....	.013	.013
15. Total nitrogen in gases.	N_2	4.473	1.923	....	....	.013	6.409
16. Carbon dioxide formed	CO_2	.591	.290	....	.251	....	1.132
17. Total dry gases	..	5.064	2.213	....	.251	.013	7.541
18. Water vapor formed	H_2O	1.182	.435	....	....	....	1.617
19. Total wet gases	..	6.246	2.648	....	.251	.013	9.158

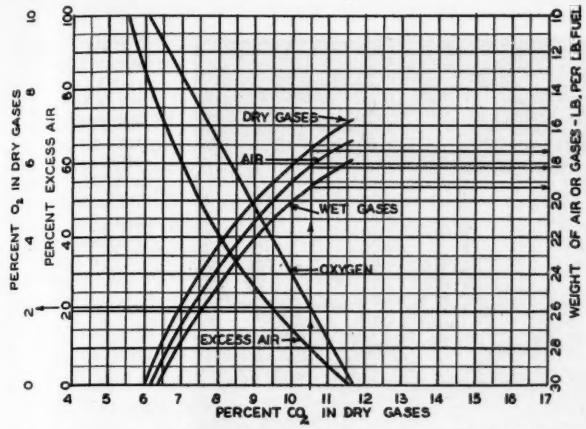


FIG. 1. COMBUSTION CHARACTERISTICS OF NATURAL GAS SAMPLE NO. 1

2. Dry Gases.

$$.985\ CO_2 + (7.456 + .015 + 2.980)\ N_2 + .788\ O_2 = 12.224 \text{ Mols dry gases.}$$

3. Per Cent CO_2 and O_2 in Dry Gases.

$$\frac{.985}{12.224} = 8.05 \text{ per cent } CO_2$$

$$\frac{.788}{12.224} = 6.44 \text{ per cent } O_2$$

The molecular weight of the dry gases is 29.54 and the pound of dry gases, water vapor, and air per pound of fuel gas may be determined as shown above and are respectively, 22.32, 2.20, and 23.52.

All of these calculations may be conveniently arranged in a standard form table as shown in Tables III to VIII. The sequence in the table is the sequence of the calculations and any one set of calculations may be completed in a short time. The results in Tables III, IV, VI and VII are all mols or volumes per mol or volume of fuel gas.

TABLE VII. CALCULATIONS FOR THE COMBUSTION OF NATURAL GAS SAMPLE NO. 8 WITH 40 PER CENT EXCESS AIR

		Mols or Volumes per Mol or Volume of Gas					
		CH_4	C_2H_6	C_3H_8	CO_2	N_2	Total
1. Carbon in fuel gas.....	C	.591	.290	....	.251	....	1.132
2. Hydrogen in fuel gas.....	H_2	1.182	.435	....	....	....	1.617
3. Nitrogen in fuel gas.....	N_2	....	....	....	....	.013	.013
4. Oxygen in fuel gas.....	O_2	....	....	....	.251	....	.251
5. Oxygen req. for carbon...	O_2	.591	.290	....	.251	....	1.132
6. Oxygen req. for hydrogen	O_2	.591	.218	....	....	....	.809
7. Total oxygen required	O_2	1.182	.508	....	.251	....	1.941
8. Oxygen in fuel gas.....	O_2	....	....	....	.251	....	.251
9. Oxygen unrequired air...	O_2	1.182	.508	....	....	....	1.690
10. Excess oxygen in gases	O_2	.473	.203	....	....	....	.676
11. Total oxygen supplied	O_2	1.655	.711	....	....	....	2.366
12. Total air supplied	..	7.919	3.402	....	....	....	11.321
13. Nitrogen in air supplied	N_2	6.262	2.691	....	....	....	8.953
14. Nitrogen in fuel gas..	N_2	....	....	....	....	.013	.013
15. Nitrogen in gases, total..	N_2	6.262	2.691	....	....	.013	8.966
16. Carbon dioxide formed	CO_2	.591	.290	....	.251	....	1.132
17. Total dry gases	..	7.326	3.184	....	.251	.013	10.774
18. Water vapor formed	H_2O	1.182	.435	....	....	....	1.617
19. Total wet gases	..	8.508	3.619	....	.251	.013	12.391

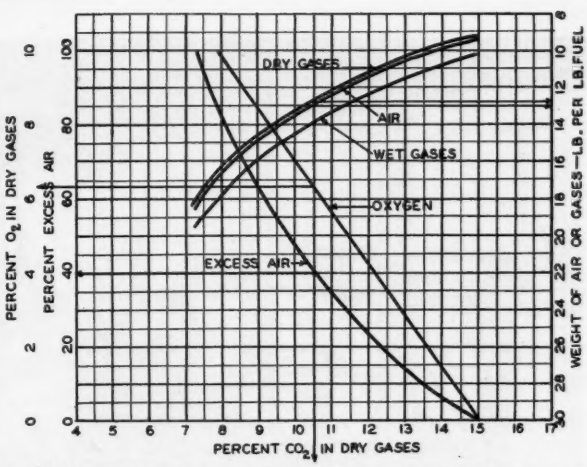


FIG. 2. COMBUSTION CHARACTERISTICS OF NATURAL GAS SAMPLE NO. 8

These tables show in detail the air requirements of each constituent of the fuel and the source of each constituent of the gases formed by combustion.

Tables V and VIII give the summarized results on both a weight and volume basis.

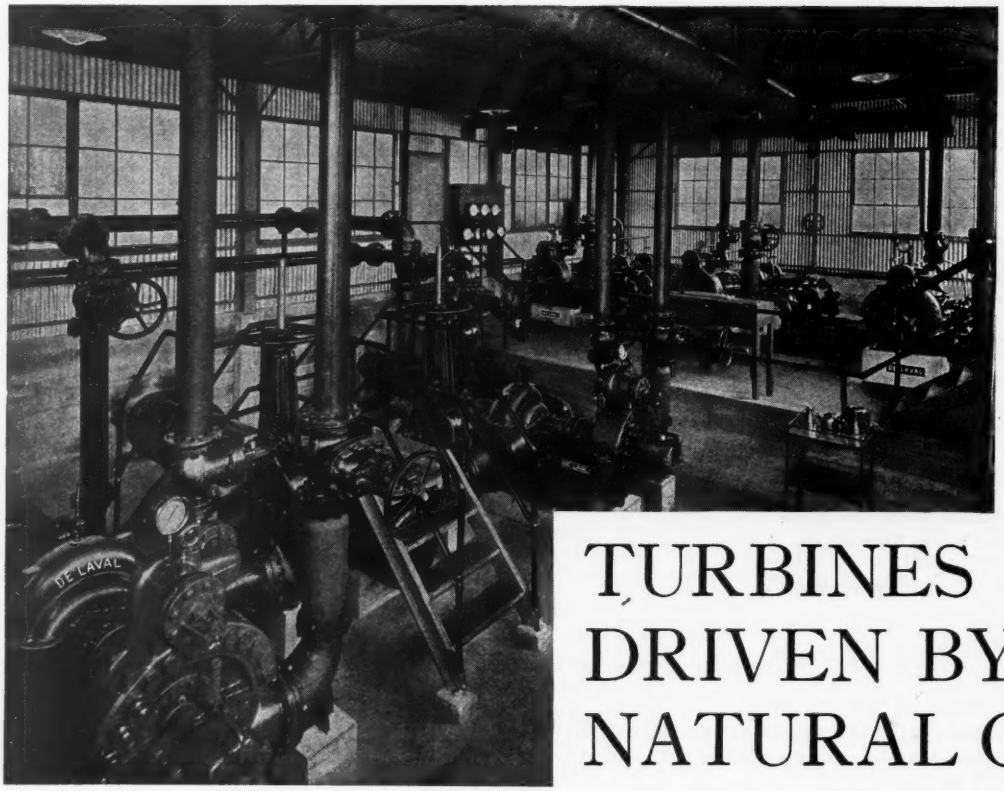
In Figs. 1 and 2 the weight of air required, the weight of gases formed, and the resulting percentage of CO_2 and O_2 are plotted against per cent excess air. These characteristic charts give a complete picture of the combustion of the gas in question, under any normal operating conditions.

Note that the percentage of CO_2 in the waste gases is not even the approximate indicator of good combustion with these natural gas fuels that it is with coal. The percentage of O_2 is more reliable in this respect. Thus, 10.5 per cent CO_2 in the waste gases from Sample No. 1 indicates very good combustion with only 10 per cent excess air, whereas 10.5 per cent CO_2 in the case of Sample No. 8 indicates only fair combustion with 40 per cent excess air. Yet paradoxically, the weight of gases formed per pound of fuel gas when burning No. 8 with 40 per cent excess air is only three-fourths of the weight of gases formed when burning No. 1 with only 10 per cent excess air.

Specific heats of the waste gases and the calculation of the theoretical flame temperatures, will be dealt with in the next article of this series.

TABLE VIII. COMBUSTION CHARACTERISTICS OF FUEL GAS SAMPLE NO. 8

Excess Air— Per cent by wt.	0	20	40	60	80	100
Fuel gas—lb.	1.00	1.00	1.00	1.00	1.00	1.00
Air—lb. per lb. fuel gas	9.25	11.10	12.93	14.80	16.65	18.50
Dry gases—lb. per lb. fuel gas	9.09	10.92	12.78	14.61	16.45	18.34
Water vapor—lb. per lb. fuel gas	1.16	1.16	1.16	1.16	1.16	1.16
Wet gases—lb. per lb. fuel gas 10.25		12.08	13.94	15.77	17.61	19.50
CO_2 in gases—per cent by vol. 15.01		12.35	10.52	9.15	8.08	7.24
O_2 in gases — per cent by vol.	0.00	3.70	6.28	8.20	9.65	10.81
Molecular wt. of dry gases 30.40		30.12	29.95	29.82	29.65	29.59
Fuel gas—cu. ft. (32° F. and 14.7 lb.).....	1.00	1.00	1.00	1.00	1.00	1.00
Air—cu. ft. per cu. ft. gas	8.09	9.70	11.32	12.94	14.55	16.17
Dry gases—cu. ft. per cu. ft. gas.....	7.54	9.15	10.77	12.38	14.01	15.63
Water vapor — cu. ft. per cu. ft. gas.....	1.62	1.62	1.62	1.62	1.62	1.62
Wet gases — cu. ft. per cu. ft. gas.....	9.16	10.77	12.39	14.00	15.63	17.25
Density of dry gases— lb. per cu. ft.....	.0844	.0839	.0835	.0831	.0827	.0823



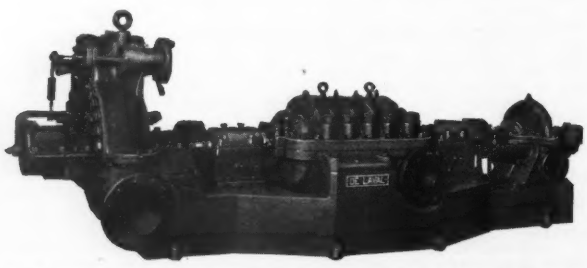
PUMP ROOM SUPERIOR OIL CO.'S PLANT AT KETTLEMAN HILLS, CAL. HUFFMAN NO. 1 WELL. GAS PRESSURE, 275 LB. BACK PRESSURE 75-0 LB.

TURBINES DRIVEN BY NATURAL GAS

By C. H. Johnston

NATURAL GAS is found in the deeper producing rock strata at pressures originally as high as 3000 or 4000 lb. per sq. in., in some cases. It exists, possibly, in part as free gas but, since methane and ethane, which constitute about 75 per cent of the gas have critical temperatures below 75 deg. F., the free gas would not be liquefied. At a pressure of 1500 lb. per sq. in., however, as much as 360 cu. ft. of natural wet gas can be dissolved in a barrel of the lighter oils, so undoubtedly most of the gas is originally in solution where it is found associated with oil.

Gas in solution reduces materially both the viscosity and the surface tension of the oil, hence the resistance to flow of the oil through the rock into the well. Formation of bubbles, on the other hand, creates resistance to flow and production may even cease because the gas pressure has been so reduced as to cause the production of bubbles in the oil, rather than because the oil has been exhausted. For each well there is a certain back pressure which gives a minimum gas to oil output ratio. While increasing the back pressure on the well reduces the daily production, it will frequently, by reducing the gas to oil ratio, increase considerably the ultimate recovery of oil. At certain times in the life of a well, increase of back pressure may actually increase the daily output.



GAS-OPERATED TURBINE DRIVING MULTI-STAGE PUMP, 475 G.P.M. AT 520 LB. AND SINGLE-STAGE 320 G.P.M. AT 90 LB.

Inasmuch as it is desirable from the standpoint of production to hold some back pressure on the gas delivered from a well, it has been obvious to seek uses for the energy represented by this back pressure. Gas under pressure has been used in some instances in gas lifts for pumping other wells, also for repressuring other wells and for forcing the gas through pipe lines to points where it could be sold. As it comes from the well, "wet gas" is passed through an absorption process which removes all gasoline content, together with water and dirt. Although the gas issues from the well at a much higher pressure, absorption plants are designed to operate some at 400 to 500 lb., others at still lower pressures.

In the Kettleman Hills field in California, the first absorption plant built in 1929 was equipped with a modern boiler equipment to provide steam for turbines driving the centrifugal oil and water pumps and for process work. It was soon found that the water available for boiler use was of poor quality, so that, even after water-softening equipment had been installed,

much trouble was experienced with the boiler tubes, also the steam entering the turbines carried large quantities of moisture and sludge.

Abundance of natural gas at a pressure of 400 lb. per sq. in. going to waste naturally suggested its use instead of steam in turbines. The problem was submitted to the De Laval Steam Turbine Co., Trenton, N. J., and after some research turbines were fitted with nozzles of special form in order to take advantage of the expansion characteristics of gas, which are different from those of steam. Gas, which comes from one of the largest gas producing wells in California, reaches the turbine at around 275 lb. per sq. in. As the owner of the plant had a contract to supply fuel gas to neighboring drilling rigs at 70 lb. pressure, the nozzles were designed to expand the gas to 75 lb. back pressure. At other plants, as in the Elwood field, turbines are operated at pressures as low as 45 lb.

Low-pressure waste steam being also available, it was used for heating the gas to approximately 190 deg. F., thereby materially increasing the energy available from the expansion of the gas and eliminating possibility of frosting due to the refrigerating effect of expansion, as the gas left the turbines at well above 80 deg. F. One plant at Kettleman Hills, however, has no installed heaters and no trouble from frosting has been experienced, the gas entering the turbine at a temperature in the neighborhood of 125 deg. F.

This turbine installation has now been in operation for over 2 yr., giving uninterrupted service. Recently, when opened for inspection, the turbines showed no wear on interior parts such as nozzles, guide vanes and buckets. All pumping for circulation of oil and water is performed by gas-turbine-driven pumps, the gas-driven units proving so reliable that no motor or steam-driven pumps have been installed for standby service and only enough boiler capacity to take care of stills and of three small reciprocating pumps.

In the majority of the plants in the Kettleman region, more than enough gas is available to do all pumping, including rich and lean oils, wild gasoline to stabilizers and water over cooling towers and through compressor jackets. Some fifteen or twenty additional gas-driven turbines have been installed in various plants other than the one described, all giving economical service and eliminating boilers and boiler attendance.

"THE PUMP does not function properly. Please send engineer to correct trouble."

This was the gist of a telegram received by the Worthington Pump Co. from one of its customers who had just had new pump equipment installed. At the time the work was done, the Worthington erecting superintendent had an excellent installation photograph made. On receipt of the wire, the installation photograph was taken from file and closely scrutinized. The photograph revealed the cause of the trouble. The air valve links and the eccentric rod connection to the two rocker arms had been interchanged from the position indicated on the elevation drawing. Instead of an engineer, a wire was sent suggesting that the connections be reversed. This was done, and the pump operated properly. While this is not an ordinary instance, it serves as a reminder of the importance of installation pictures, which are also of primary importance for their value in advertising.

Reclaiming Heat from Blowdown

IN USING continuous blowdown systems on boilers for controlling concentration of boiler water, heat reclaimers or exchangers are often employed to recover the heat in the water blown from the boiler. One of the recent developments in this type of equipment is the flash type heat reclaimer recently placed on the market by National Aluminate Corp. of Chicago, Ill. One of the common methods of using it is shown in Fig. 1.

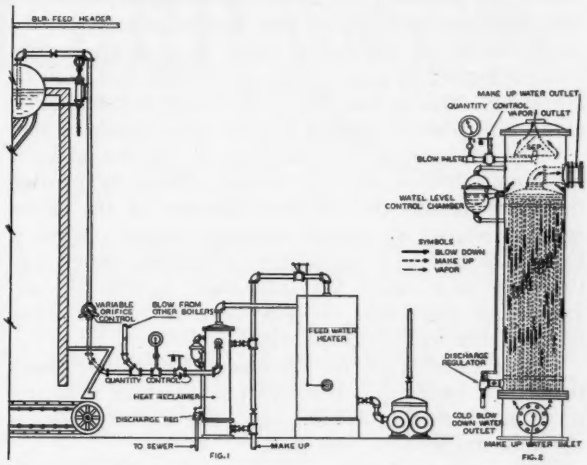


FIG. 1. GENERAL ARRANGEMENT FIG. 2. RECLAIMER

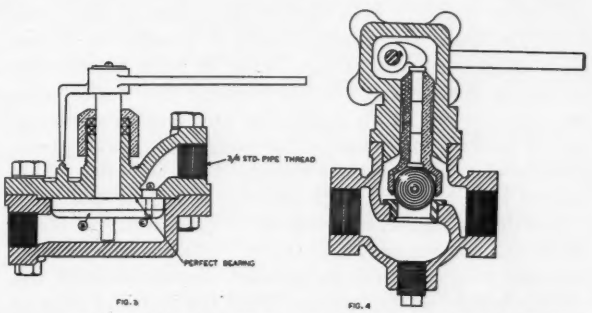


FIG. 3. VARIABLE ORIFICE FIG. 4. QUANTITY CONTROL

With this type of installation, the blowdown water passes into a low-pressure flash chamber located at the upper end of the heat reclaimer as shown in Fig. 2. This heat reclaimer is designed to cause from 15 to 25 per cent of the blowdown water at usual pressures and more at higher pressures to flash into vapor which may be used for low-pressure heating or returned to the heater or low-pressure system as pure vapor. The flash chamber is equipped with a water level control to operate automatically a discharge regulator, this arrangement being designed to prevent carry-over or blowdown water proper. The remaining blowdown water then passes around the heat exchange tubes where the incoming makeup water takes up the heat to be returned to the boiler. The manufacturer recommends this type of equipment for plants that have a deficiency of exhaust steam or where heater temperature cannot be maintained without the use of live steam.

Baffles and diffusers are provided in the reclaimer for preventing short-circuiting on the blowdown water.

In general, copper tubing is used in the construction of these heat reclaimers, the gage depending upon the type. For single-stage installations with the reclaimer between the feed pump and the boiler, 16-gage copper is ordinarily used for pressures up to 300 lb. For the flash type machine, 18-gage copper is usually heavy enough. All castings are of steel or semi-steel, depending upon the pressure.

Two features of this heat reclaimer installation are the variable orifice control and the quantity control shown in Figs. 3 and 4. The variable orifice control is designed to provide a mechanism whereby the blowdown discharged from a given boiler can be regulated to suit the operating conditions of that particular unit and the concentration of the boiler water at any given time without regard to any of the other units that may be operating. This is done by a valve with a fixed orifice at A, with plate B rotated by the valve handle so that a series of holes of various sizes, C, in the plate is superimposed over the fixed orifice. Thus, by turning the valve handle, the effective diameter of the orifice can be reduced by several successive steps. When a battery of boilers is discharging blowdown water continuously to a single heat exchanger system, the advantage of controlling the blowdown from each boiler to fit its own conditions is obvious.

These variable orifices are made of semi-steel tested to 2000 lb. hydrostatic pressure for operating pressures up to and including 300 lb. gage. For higher pressures the units are made of cast steel.

The purpose of the quantity regulator is primarily to maintain the back pressure on the discharge side of the orifice plate, to hold the pressure drop to the plate to a low figure and thus to make it possible to utilize much larger orifice openings. This, in turn, is intended to reduce greatly the velocity through the orifice, consequently to cut down materially any erosive tendency and to minimize the chances for clogging by small pieces of scale that might become dislodged in the boiler. This control is in reality a back-pressure regulator and with it practically micrometer control of the volume of blowdown can be obtained, it is stated. The variable orifices are used to synchronize the desired concentration of the various boilers of the battery, while the quantity regulator is used to vary the total volume of blowdown from all boilers, depending upon changes in the composition of the makeup, load and so on.

Construction of this quantity control is shown in the cross section. The cam, actuated by the valve lever, presses on the stem of the valve and, in closed position holds the ball against the seat. A weight can be moved along the valve lever so that the pressure of blowdown water entering the valve will hold the ball off the seat to produce an opening of the amount desired. This quantity regulator is made of a cast steel body, bronze fitted, with monel seat and ball.

Ahead of the quantity control an indicating gage is placed to indicate the pressure drop through the orifice, thus aiding adjustment of the quantity control. Under normal operation, there is usually a pressure drop of about 25 lb. through the plate, although this may be varied to suit the conditions. As can readily be seen, two or more boiler pressures may be connected to the same header by using a quantity control for each pressure.

Bituminous Coal Conference at Carnegie Tech

IMPORTANT DELEGATIONS of fuel technologists from the principal European countries will attend the Third International Conference on Bituminous Coal at the Carnegie Institute of Technology, Pittsburgh, Pa., on November 16 to 21, according to Dr. Thomas S. Baker, president of the Institute of Technology and organizer of the congresses.

Conferences with scientists in the coal centers of Europe during a two months' visit assured Dr. Baker of the interest and coöperation of fuel technologists on the continent. Success of the two preceding meetings that have been held in Pittsburgh has indicated the importance of the conference as occasions where outstanding scientists throughout the world may explain and discuss their discoveries.

The program of the third meeting, embracing the more important topics in fuel technology now being considered throughout the world, is progressing rapidly. Since Dr. Baker's return from Europe he has devoted his time to arranging the American program as well as to corresponding with scientists in Europe. In America great progress has been made in research since the last conference in 1928, and the program this year will contain announcements of significant developments made in research laboratories in the United States.

Special efforts are being made by the committee in charge to arrange inspection visits to the important research laboratories and industrial plants in Pittsburgh and other parts of the country in connection with the conference.

Fuel technologists who wish to contribute papers to the conference are urged to apply to the Secretary as soon as possible as the program is rapidly being compiled.

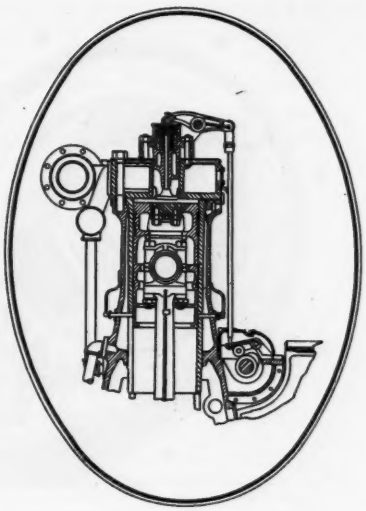
A group of prominent American men of affairs will assist Dr. Baker in an advisory capacity in organizing the meeting. The personnel of this advisory board follows: James A. Farrell, president of the United States Steel Corp.; John Hays Hammond, prominent mining engineer; Samuel Insull, public utilities magnate; Dr. Frank B. Jewett, president of the Bell Telephone Laboratories, Inc.; Hon. A. W. Mellon, secretary of the U. S. Treasury and capitalist; F. A. Merrick, president of the Westinghouse Electric & Manufacturing Co.: Auguste G. Pratt, president of the Babcock and Wilcox Co.; H. B. Rust, president of the Koppers Co.; Matthew S. Sloan, president of the New York Edison Co.; Gerard Swope, president of the General Electric Co.; and Walter C. Teagle, president of the Standard Oil Co. of New Jersey.

Calculating the Strength of Gear Teeth

IN THE horsepower formula Eq. 13, page 469, April 15, 1931 issue, d is the pitch diameter in inches.

FIXED CHARGES usually include interest on the investment, depreciation, taxes and insurance. These remain constant regardless of production or output.

DIESEL ENGINE UPKEEP



PART XII. VALVE GEAR ADJUSTMENT, METHODS OF AVOIDING WEAR AND OF REMOVING AND REPLACING PARTS. VALVE GEAR FEATURE TYPES. ROLLER CLEARANCE EFFECT AND MEASUREMENT.

BY EDWARD J. KUNZE

VALVE GEAR maintenance differs little from that of any other mechanism. There is little to wear when proper lubricating methods are used and there should be no breakage in this mechanism as rigidity is a prime requisite. Valve gears are usually designed heavy enough to avoid distortion, therefore they cannot break except under abnormal accidental conditions.

It is to provide stiffness without excessive weight that push rods are frequently made of seamless tubing with welded forged-steel ends. This expedient is used especially for exhaust valves because of the greater force required to open those valves.

KEEP FASTENINGS TIGHT AND OIL HOLES CLEAN

Valve gears, however, should be examined and adjusted every two or three months. All keys and set screws should be examined to see if they are in place and secure. If any fits have become corroded, they should be cleaned up and made free. If any pins or bushings show excessive clearance, the bushings should be renewed and, if necessary, the pins should be replaced. All oil holes should be cleaned out.

Camshafts are usually driven from the crankshaft by gears or silent chains. Spur, bevel, helical or twisted gears are generally used for gear drives; helical and twisted gears have the usual advantage of sliding contact hence they are more noiseless in action and avoid impact.

COMPOUNDING GEARS REDUCES WEAR

Prevention of local wear of the gears due to repeated application of a heavy load on the same pair of teeth during the opening of the exhaust valve is accomplished by compounding the gears in such a way that there will be a "hunting tooth" in the system. Four-cycle engines must have a one-to-two ratio between the crankshaft and camshaft, hence the camshaft gear has twice the number of teeth of the crankshaft gear; the number of teeth on the intermediate gears has no effect on the final speed. The hunting effect may be secured, therefore, by proper selection of the two pairs of gears, one pair having, for example, 24 teeth on the driving and 25 teeth on the driven gear; the second set having 25 teeth on the drive and 48 teeth on the follower. In this case the ratio will be $(24 \times 25) \div (25 \times 48) = \frac{1}{2}$. Wear in this case will be distributed evenly over all of the teeth of any one gear.

With such a set of gears, some adjustment is possible. One tooth of the crankshaft gear is equal to $360 \div 24 = 15$ deg. while one tooth of the camshaft gear is equal to $360 \div 48 = 7\frac{1}{2}$ deg. If, due to wear or other cause, it is desired to advance the time of the crankshaft, the camshaft gear may be advanced one tooth (15 deg.) and the crankshaft gear retarded one tooth ($7\frac{1}{2}$ deg.) giving a net advance of $7\frac{1}{2}$ deg. Retardation of the time of the crankshaft may be obtained in a similar manner by retarding the camshaft gear one tooth and advancing the crankshaft gear one tooth.

REFERENCE MARKS AID REPLACEMENT

If the gears or camshaft have not been so marked by the engine builder that they may be returned without difficulty to their original setting, this should be done before removal of the camshaft. To do this properly, place a crank on top dead center and mark the camshaft with reference to some fixed point such as a mark on a bearing.

Although the operating engineer has little to do with actual engine valve setting, wear of parts after years of operation, particularly where helical gearing is used causing thrust collars to wear and throw the entire camshaft out of time, may take place. Backlash in the gearing also has a detrimental effect on the injection cam action causing the fuel valve to open late and close early, thus decreasing the actual open time. Replacement of the fuel-cam nose by one having a longer open time will partially overcome this defect but it is better to provide new gears. Wear on these parts is indicated by the action of the fuel valve.

SILENT CHAIN DRIVES

Quiet operation, efficiency and flexibility are characteristics claimed for silent-chain drives by their manufacturers. Replacement of a chain is a quick and easy operation when it is made properly and slight alteration of the center to center distance between the shafts due to wear or other cause, does not affect the

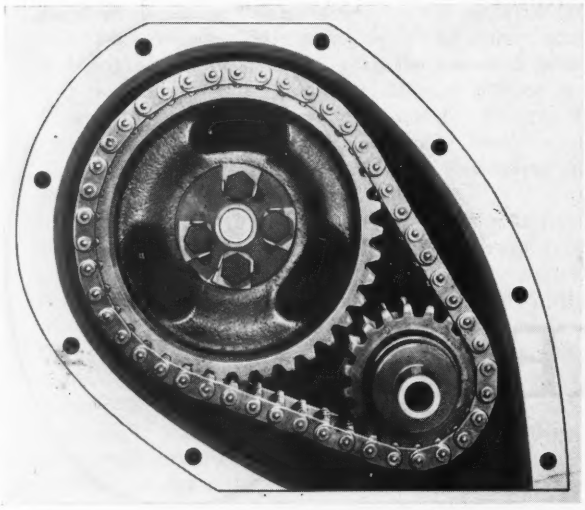


FIG. 1. CHAIN DRIVE WITHOUT IDLER

performance of the chain. Chains suitable for this type of drive are constructed in such a manner as to reduce possibility of wear and are made up of specially heat-treated steel parts but care must be observed that lubrication is functioning properly and that the chain is properly serviced. Quality as well as quantity of lubricant used will have a great deal to do with the life of the chain.

Three types of chain drives are in general use: That with fixed centers having no provision for adjustment of chain tension as shown in Fig. 1; that provided with hand adjustment of chain tension as shown in Fig. 2 and that with automatic adjustment, Fig. 3.

Replacing Chain Drives Without Altering Setting

One method of replacing chains without changing the timing of the camshaft and fuel pumps is to scribe lines on the teeth of the sprockets at a point where the chain comes on or off. The number of pins on the chain between the lines on the sprockets should be counted carefully and the new chains installed with exactly the same number of pins between the lines as

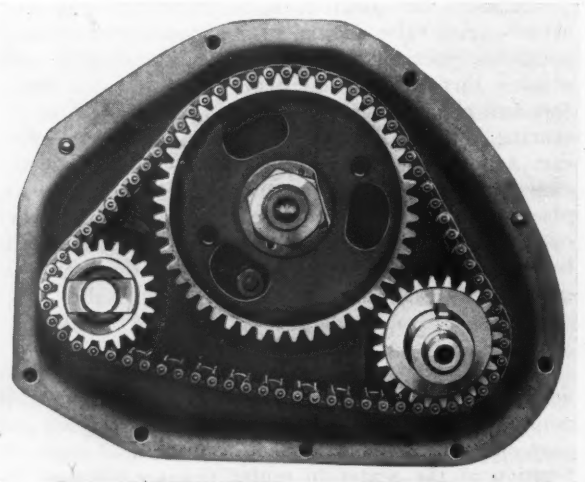


FIG. 2. CHAIN DRIVE WITH FIXED IDLER

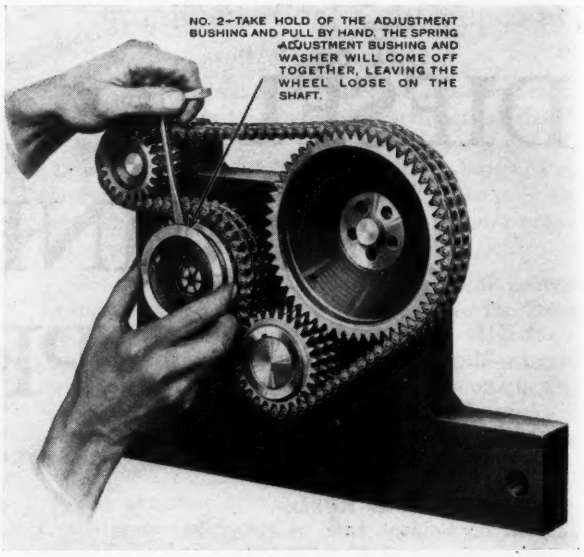

NO. 2—TAKE HOLD OF THE ADJUSTMENT BUSHING AND PULL BY HAND. THE SPRING ADJUSTMENT BUSHING AND WASHER WILL COME OFF TOGETHER, LEAVING THE WHEEL LOOSE ON THE SHAFT.

FIG. 3. CHAIN DRIVE WITH AUTOMATIC ADJUSTMENT SHOWING HOW BUSHING AND SPRING ARE WITHDRAWN

before. Where the fuel pump is driven from an auxiliary shaft, this procedure should apply to all three sprockets.

Removal of the chain from a chain drive with automatic adjustment as shown is accomplished by withdrawing the cotter pin from the idler sprocket hub then forcing out the bushing and spring as shown in Fig. 3, then removing the sprocket by relieving it from the chain which has been given slack through the previous removal of the bushing. The chain now can be lifted from the remaining sprockets of the drive without difficulty.

Installation of a new chain of this type is accomplished in the reverse order. After turning the bushing around the shaft in the same direction that the spring tends to turn it until all slack is out of the chain, a spring winder, Fig. 5, which catches the inside end of the spring in the spring-winder slot, is used to give the spring 1½ complete turns and the spring end is pushed into the nearest slot in the end of the shaft. The washer and cotter pin are then replaced.

Cams suffer little wear since they are usually made of hardened and ground steel. It is rare that there should be any need of changing the form of the cam but this can be done by grinding or by building up the surface where desired by autogenous welding followed by grinding. As a rule, it is better to order new parts from the builder. The cost of alteration or replacement in this case may appear to be unwarranted but if the specific case is analyzed, it may show such procedure to be a good investment. Suppose an 800-hp. engine is purchased at $100 a horsepower installed. If there is a 5 per cent loss of capacity because of improper valve setting, the loss will amount to $4000. While it may be possible for the engine to pull the required load with improperly timed valves, it would do so at a greater cost for fuel and maintenance.

Cam Types

Cams may have tangential flanks as in Fig. 6, convex flanks as in Fig. 7 or concave flanks as in Fig. 8 according to the desired conditions of opening and closing of

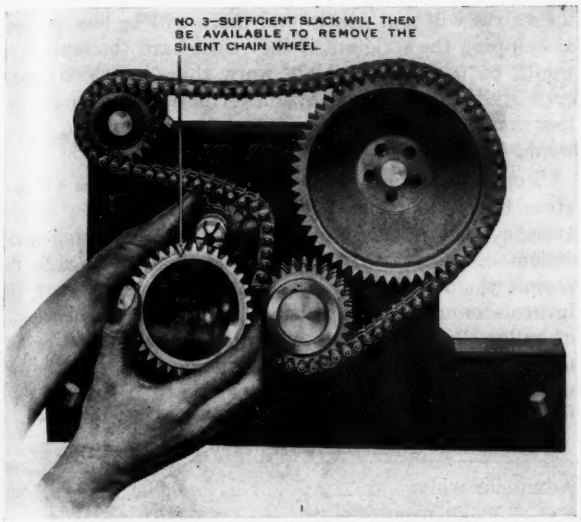


FIG. 4. SPROCKET IS REMOVED WITH SLACK CREATED BY PREVIOUS REMOVAL OF BUSHING

the valve. Formerly tangential-flank cams were made most easily. As cams are now ground to conform automatically to the shape of a master cam, one shape is as easily obtained as another.

Contact between cam and follower is introduced more gradually by a concave-flanked cam and quicker motion is transmitted to the follower during the opening and closing processes but a convex-flanked cam causes the valve to be open a greater amount of time during any one cycle. The valve gear should start the valve in motion gradually or shock will result, the mechanism will be noisy and excessive wear will result. The cam and follower, therefore, should come into contact gradually. Exhaust cams may be distinguished from inlet cam by the wider nose, Fig. 9, which causes the valve to be held wide open during the dwell period.

Pivoted followers cause the opening and closing of

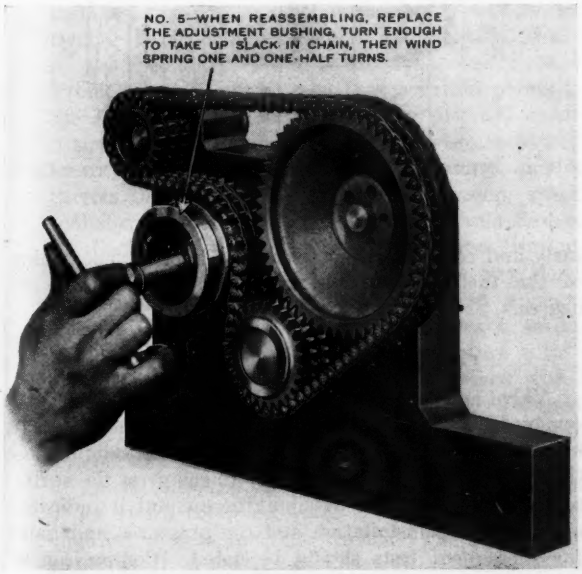

NO. 5—WHEN REASSEMBLING, REPLACE THE ADJUSTMENT BUSHING, TURN ENOUGH TO TAKE UP SLACK IN CHAIN, THEN WIND SPRING ONE AND ONE-HALF TURNS.

FIG. 5. BUSHING IS REPLACED WITH CHAIN SLACK TAKEN UP AND SPRING IS THEN WOUND 1½ TURNS

the valve to be unsymmetrical because, as shown in Fig. 6, the maximum lift will be reached before half of the period of valve movement has elapsed.

Since inlet and exhaust valves are removed periodically for cleaning and grinding, it is desirable that this may be done without disturbing the setting of the valve gear and the cam clearances. To accomplish this a two-part rocker-arm lever, Fig. 10, is used. The two parts

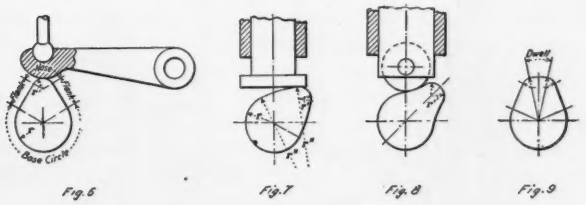


FIG. 6. TANGENTIAL CAM WITH PIVOTED FOLLOWER
FIG. 7. CONVEX-FLANK CAM WITH FLAT FOLLOWER
FIG. 8. CONCAVE-FLANK CAM WITH ROLLER FOLLOWER
FIG. 9. EXHAUST CAM DETAIL SHOWING DWELL PERIOD

of this lever are joined with two dowel pins and held together by a bolt as shown. By removing the bolt and the upper part of the rocker-arm lever, the entire valve and cage can be removed without changing the valve gear setting.

Rocker-Arms

Rocker-arm mechanisms are quite similar for engine valves of all makes of vertical engines. Most variation exists in the starting valve operating mechanism. Some clearance is necessary in this mechanism to assure proper

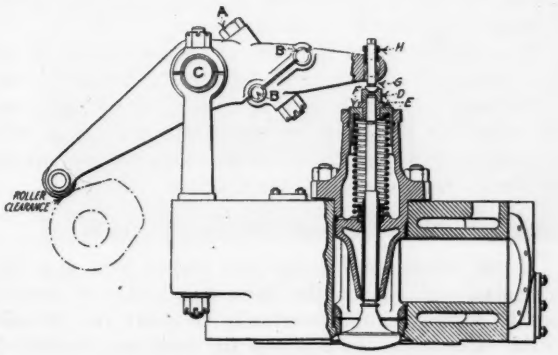


FIG. 10. TWO-PART ROCKER-ARM LEVER WHICH PERMITS REMOVAL OF VALVE WITHOUT CHANGING THE ADJUSTMENT OF THE VALVE GEAR

seating of the valve. This clearance may be given at the cam end of the rocker arm as is done in the mechanism illustrated in Fig. 11, where a ball and socket connection is made between rocker arm and valve stem or the clearance may be between a roller on the rocker arm and the valve stem as shown in Fig. 12.

Valve Tappets

Valve spindle ends may be used directly as valve tappets in which case these ends generally are case hardened or a hardened nut screwed on the end of the spindle and serving also as a retainer for the spring cap, may be used. If no nut is used, the spring cap may be retained by means of semi-circular split rings

which may be either of rectangular or wedge-shaped cross section as shown in Fig. 13. To remove the spring, it is compressed until the split ring is uncovered after which the halves of the ring can be taken out of the groove. The cap and spring then may be slid off of the stem. This arrangement is convenient but it is too light

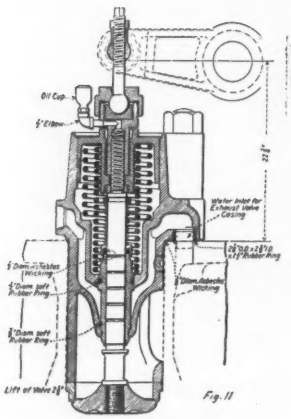


FIG. 11. BALL AND SOCKET CONNECTION WITH VALVE STEM

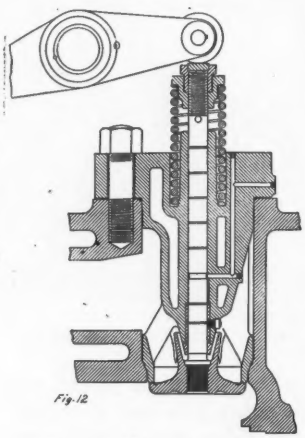


FIG. 12. ROLLER ON ROCKER ARM CONTACTS VALVE STEM DURING OPEN POSITION

for large valves because of the heavy forces involved in opening such valves.

Check nuts placed below the tappet nuts generally are used to secure them and serve as retainers for the spring cap. Rigid tappet screws also may be locked by means of a saw cut, in the boss of the rocker arm, which is pinched together by a small screw.

It is essential that the ends of tappets should be of good material and properly hardened because of the severe service to which they are subjected. If they are soft they will wear rapidly resulting, perhaps, in battering loose the tappet nut on the valve spindle, allowing the latter to drop into the cylinder.

Large Clearance Results in Shock

If the clearance between the rocker arm and the valve-stem nut is large, the blows struck at each contact may be severe enough eventually to shear the threads on the valve stem. In this case the stem may be turned down and threaded at the end for a smaller nut or a taper cotter pin may be driven through the worn nut.

Bushings on the rocker-arm pins are also subject to wear particularly if insufficiently lubricated. They should be replaced before they are badly worn. The pins should be replaced also if they become flat, using case-hardened steel for the purpose. Use of small oil cups on the pin bearings assures better lubrication than is likely if oil holes without cups are employed.

Too much roller clearance on engine-valve mechanisms may set up a knock in the cylinder because it does not get its air quickly enough in the first case and it does not expel its exhaust gases quickly enough in the second case.

Roller Clearance Influences Valve Tightness

Amount of roller clearance affects the length of time a valve may remain tight. If the clearance is small, the valves will seat gently and there will be less chance of chipping the scale but if they close hard the tendency would be to keep the scale worn thin, in which case, even if it did chip, the likelihood of leakage would be less than if the scale is thick and burning of the valve would be less likely.

Roller clearances vary with different makes of engines but, as a general rule, sufficient clearance is allowed to take care of expansion under the varying conditions of temperature and it is kept small enough to permit the valves to seat quietly but large enough to insure seating under operating conditions. Adjustment of roller should be made while the engine is hot as in operation. Standard thickness gages serve best for measuring the clearance.

Clearances usually allowed vary as follows:

Admission valve	0.005	to 0.04	in.
Exhaust valve	0.01	to 0.04	in.
Fuel injection valve	0.001	to 0.004	in.
Starting valve	0.01	to 0.04	in.

Adjustment of roller clearance to alter timing should be done for investigation only. If considerable change in timing is required, it should be made by changing the cams. Improper adjustment of roller clearance on the fuel-valve mechanism may cause considerable trouble. Too little clearance may prevent the valve from seating tightly or cause the fuel valve to open too early and result in pre-ignition and knock. The timing of the fuel valve should be accurate to within one degree.

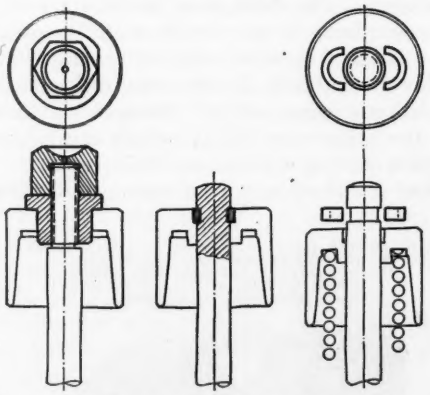


FIG. 13. METHODS OF SECURING SPRING CAPS TO VALVE SPINDLES

Valve Springs Should Be Checked

Valve springs should be tested each time valves are removed. Data concerning this are most conveniently kept for each spring on a filing card. This should show the amount of pressure necessary to compress the spring to a stated amount, if possible, the amount it indicated at the time of installation and the pressures and dates for subsequent tests should be noted. Comparison of this data gives an indication of when replacement by a new spring is most desirable.

New District Heating Plant for Dayton

DAYTON POWER & LIGHT CO. ADDS LONGWORTH STREET STATION TO TAKE CARE OF INCREASED DEMANDS

DAYTON, O., has had a district steam heating system since 1908 and while the city ranks forty-third in the country in population, its heating system is the sixth largest on the basis of maximum demands, is fifth in number of steam customers and fourth in volume of seasonal sendout. Furthermore, the system is unique in that it has expanded until at the present time there is but one major building in the heating district not

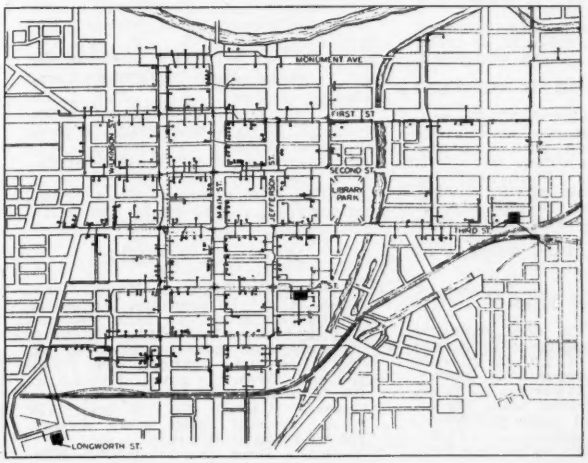


FIG. 1. SERVICE MAP OF THE DAYTON POWER & LIGHT CO. DISTRICT HEATING SYSTEM

heated by steam supplied by The Dayton Power and Light Co.

Up to the present time steam was supplied by two plants, Third St. and Fourth St. Stations, having an installed capacity of 8311 b-hp. and 1500 b-hp. respectively. In order to keep up with the continued growth, it was necessary to add additional boiler capacity. From Fig. 1 it can be seen that both old plants are in the eastern portion of the heating district, making it desirable to locate the new plant at the southwest extremity. A site was found at Longworth and Eaker Streets, having ample room for expansion, space for coal storage and adjoining the Pennsylvania Railroad.

As the new plant is opposite the Union Station and visible from the business district of the city, considerable thought was given to its external appearance. The building, Fig. 2, greatly resembles a mediaeval castle as it is of French Gothic architecture with walls of buff brick varying in shade and trimmed with Bedford limestone. The present building is designed for two boiler units with provision for extending the building for two additional units.

Initial installation consists of one 225-lb. Stirling boiler and a complete water treating and coal and ash handling system for four boilers. The boiler unit has 15,000 sq. ft. of heating surface and includes a 238-sq. ft. Bailey water-cooled bridge wall and a 12,360-sq. ft. tubular air heater and no superheater. Side walls along the stoker are lined with silicon carbide air-cooled blocks but a few feet above this a side wall supporting beam with suspended wall construction is installed. The setting has been designed throughout to operate at a boiler output of 150,000 lb. of steam per hour.

The boiler is fired by an 11-retort and 41-tuyere Taylor stoker with double 18-in. crusher rolls. The stoker is driven by either a steam turbine or an electric motor and the crusher rolls by oil-operated pistons. The operation of the stoker has been satisfactory with 390 deg. F. preheated air and in spite of the high air temperature there has been less maintenance than with other stokers in the older plants.

Forced and induced draft fans are turbine driven and have a capacity of 60,000 c.f.m. at 9 in. and 120,000 c.f.m. at 7 in. static pressure respectively. The induced

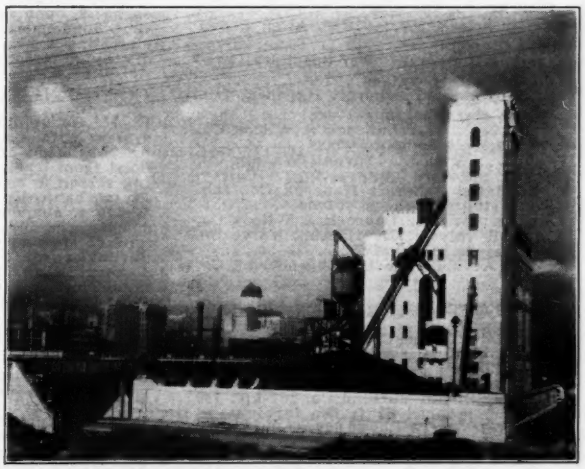


FIG. 2. THE PLANT OF FRENCH GOTHIC ARCHITECTURE IS VISIBLE FROM THE BUSINESS DISTRICT

draft fan is of the cinder eliminating type with automatic control for the turbine throttle valve. The forced draft fan turbine is controlled by a motor-operated valve remotely controlled from the boiler panel board.

COAL AND ASH SYSTEM

Coal is discharged from cars to a track hopper suspended from the trestle and then into a Beaumont 100-t. per hr. skip bucket which elevates it to a hopper at the top of the coal tower. From this hopper the coal drops to a shaking screen and then into another hopper directly above the synchronized tram car track. The tram car distributes the coal to the 840-t. suspended bunker above the firing aisle. Coal can be put in storage by bypassing the shaking screen discharging through a chute to the 7500-t. storage yard to form an initial pile for a drag scraper.

Beneath the stoker is a vitrified brick lined ash hopper, with a manually operated pivoted gate, which dis-

charges into 18-cu. ft. dump cars. Connections from the soot hopper in the boiler and from the cinder hopper under the cinder eliminating fan to the ash hopper are provided. These connections have gates which are automatically opened by the weight of the cinders. Ash cars operate on a 24-in. gage track leading to an ash skip hoist. This hoist discharges into a tank mounted above the railroad track, arranged for spouting to either trucks or railroad cars.

Water from the overhead tank passes through piston meters, which operate chemical pumps, to the tray type heaters, in connection with the lime and soda hot process water treating system. The heaters are fitted with vent condensers and are mounted on the sedimentation tank. From the sedimentation tank, the water flows through two filters to the boiler feed pumps suction header.

Mechanical Equipment of the Longworth Station

BOILER AND ACCESSORIES

1 Babcock & Wilcox Co. Class XXIV, No. 38 Stirling boiler; 15,253 sq. ft. 250 lb. maximum allowable working pressure, no superheat.
1 Babcock & Wilcox Co. tubular air heater; 12,360 sq. ft.; air 80 deg. F. to 398 deg. F.
1 American Engineering Co. Taylor underfeed, 11-retort, 41-tuyere stoker, motor and turbine driven, 334.9 sq. ft. projected area; 18-in. double crusher rolls driven by Hele Shaw pump.
1 Fuller Lehigh Co. Bailey 238-sq. ft. water cooled bridge wall.
2 M. H. Detrick Co. side walls arches.
Boiler baffles .....Power Plant Efficiency Co.
Drake air cooled silicon carbide blocks .....Drake Non-Clinkering Furnace Block Co.
Fire brick..The Chas. Taylor Sons Co.
Boiler brickwork.....Geo. Allen & Son
Soot blowers .....Diamond Power Specialty Corp.
4½-in. safety valves.....Consolidated Ashcroft Hancock, Inc.
Water alarm columns .....Babcock & Wilcox Co.
Sesure inclined gage glass.....Yarnall-Waring Co.
Steam pressure gage.....Consolidated Ashcroft Hancock Co., Inc.
Feed, stop and check valves.....Babcock & Wilcox Co.
Blowoff valves...Everlasting Valve Co.
Non-return stop valve.....Foster Engineering Co.

DRAFT AND BOILER FEED

1 Buffalo Forge Co. 120,000-c.f.m. cinder eliminating induced-draft fan, 505 deg. F., 7 in. s.p., 257 hp., 730 r.p.m.
1 Terry Steam Turbine Co. 257-hp., 730 r.p.m. induced draft fan turbine.
1 Buffalo Forge Co. 60,000 c.f.m. double width forced draft fan, 80 deg. F., 9 in. s.p., 124.5 hp., 1175 r.p.m.
1 Terry Steam Turbine Co. 125 hp., 1175 r.p.m. forced draft fan turbine.
Automatic draft control.....Bailey Meter Co.
1 Platt Iron Wks. three-stage centrifugal turbine driven boiler feed pump, 400 g.p.m., 680-ft. head, 2850 r.p.m.
1 Terry Steam Turbine Co. 138 hp., 2850 r.p.m. turbine.
1 Platt Iron Wks. four-stage centrifugal motor driven boiler feed pump, 400 g.p.m., 680 ft. head, 1750 r.p.m.
1 Westinghouse Elec. & Mfg. Co. 150 hp., 220-v., 3-phase, 60-cycle, 1750-r.p.m. induction motor.
Copes feedwater regulators.....Northern Equipment Co.
Feed pump governor..Bailey Meter Co.

WATER TREATING AND SUPPLY

2 Ponoma Pump Co. 3-stage, 1760-r.p.m., deep well pumps, of 820 g.p.m. and 1025 g.p.m. respectively.
2 Westinghouse Elec. & Mfg. Co. deep well pump motors, 220-volt, 60-cycle, 3-phase, 1760-r.p.m., 60-hp. and 75-hp. respectively.
1 Chicago Bridge & Iron Co. 100,000 gal. storage tank.
1 Power Plant Specialty Co. 70,000 gal. per hr. Vater hot process water softening plant treating with lime and soda ash supplemented with disodium phosphate. Equipment includes: 3, chemical mixing tanks; 2, proportioners (40,000 gal. per hr. each); 2, open feedwater heater with vent condensers; 1, 70,500 gal. precipitating tank; 2, Sand filters, 8 ft. dia. by 20 ft. long.

COAL AND ASH HANDLING

1 R. H. Beaumont Co. coal handling system with a capacity of 100 t. per hr. consisting of: 1, 120 cu. ft. skip hoist from track hopper to; 1, vibrating screen in coal tower to; 1, 120 cu. ft. mechanically driven tram car to; 1, 840 t. suspended steel bunker; 1, 115 t. per hr. drag scraper to a 7500 t. outside storage with reclaiming hopper and apron conveyor.
1 General Electric Co. 40/20 hp. skip hoist winder motor, slip ring type, 230 v., 3-phase, 60-cycle, 1200/600 r.p.m.
1 General Electric Co. 7½-hp. apron feeder drive induction motor, 220 v., 3-phase, 60-cycle, 1200 r.p.m.
1 General Electric Co. 60-hp. drag scraper drive induction motor, 230 v., 3-phase, 60-cycle, 900 r.p.m.
1 R. H. Beaumont Co. ash handling system with a capacity of 25 t. per hr. Ashes dumped into 2, 18 cu. ft. dump cars on track to; 1, 40 cu. ft. skip hoist to; 1, 5000 cu. ft. ash bunker discharging to railroad cars or trucks.
1 General Electric Co. 20-hp. ash skip hoist induction motor, 230 v., 3-phase, 60-cycle, 1200 r.p.m.

INSTRUMENTS AND PIPING

1 Bailey Meter Co. boiler panel including: boiler meter, multipointer draft gage, temperature recorder, draft control.
1 Bailey Meter Co. general panel including: flow meters, temperature and pressure recorders, tank level recorder.
Master gages.....Ashton Valve Co.
Ranarex CO_2 recorder....Permutit Co.
Principal valves.....Chapman Valve Mfg. Co.
Miscellaneous valves.Lunkenheimer Co.
Check valves.....Golden-Anderson Valve Specialty Co.
Chronometer valves.....Schutte & Koerting Co.
Back pressure valves...Cochrane Corp.
Reducing valves.....Foster Engineering Co.
Expansion joints.J. Kopperman & Sons
Fabricated pipe.....{Pittsburgh Piping & Equipment Co. {Walworth Co.
C. I. pipe.....U. S. Pipe & Foundry Co.
Insulation.....The Philip Carey Co.

MISCELLANEOUS

1 Worthington Pump & Mach. Corp. 300 c.f.m. 110 lb. pressure, horizontal duplex belt driven air compressor.
1 Westinghouse Elec. & Mfg. Co. 60-hp. air compressor drive induction motor, 220 v., 60-cycle, 3-phase, 1160 r.p.m.
1 Yeomans Bros. 150 g.p.m., 1750 r.p.m., 100 ft. head duplex sump pump.
2 General Electric Co. 10 hp., 1750 r.p.m., vertical sump pump motors, 220 v., 3-phase, 60-cycle.
1 Yeomans Bros. Co. 150-g.p.m., 1150-r.p.m., 30 ft. head duplex sump pump.
2 General Electric Co. 1½ hp., 1150 r.p.m. vertical sump pump motors, 220 v., 3-phase, 60-cycle.
1 Otis Elevator Co. 4000 lb. capacity, Micro-drive automatic push button elevator.
1 Link-Belt Co. Caldwell motor driven car spotter.
Blowoff tank....Graves & Marshall Co.
Stack and ducts.Graves & Marshall Co.
Oil storage equipment.....S. F. Bowser & Co.
Unit heaters.....Buffalo Forge Co.
Warehouse scale.....Fairbanks, Morse & Co.
2 General Electric Co. auto-transformers, 450 kv-a. 230/200 v.
2 Westinghouse Elec. & Mfg. Co. network type power transformers, 450 kv-a. 6900/230-115 v.
Main power and light distribution switchboard .....I. T. E. Circuit Breaker Co.
Light and power branch distribution cabinets...Powerlite Switchboard Co.
Electrical installation work.....Lesher Electric Co.

WATER SYSTEM

Feedwater for the plant is obtained from two wells, one located at the southwest corner of the coal storage yard and one in the basement of the coal tower. These wells are equipped with Pomona deep well pumps having a capacity of 850 and 1050 g.p.m. respectively, which pump to a 100,000-gal. storage tank located in a tower at the top of the building.

Hagan phosphate is used in connection with the process. It was found necessary to install a surface continuous blowdown system to maintain the proper concentration.

One motor-driven and one turbine-driven boiler feed pump, each having a capacity of 400 g.p.m., are installed at present. The motor-driven feed pump is used to maintain the heat balance.

Boiler panel contains a draft gage, a Bailey meter, recording thermometer and control for the forced and induced draft fans. This panel will be duplicated for each of the future boilers. The general panel contains

a recording thermometer, pressure gages and overhead tank water level control. Remote control for motor-operated valves in the distribution system as well as remote pressure gage and meter recorders are mounted on this general panel. Some of the motor-operated valves, pressure gages and meters are located more than

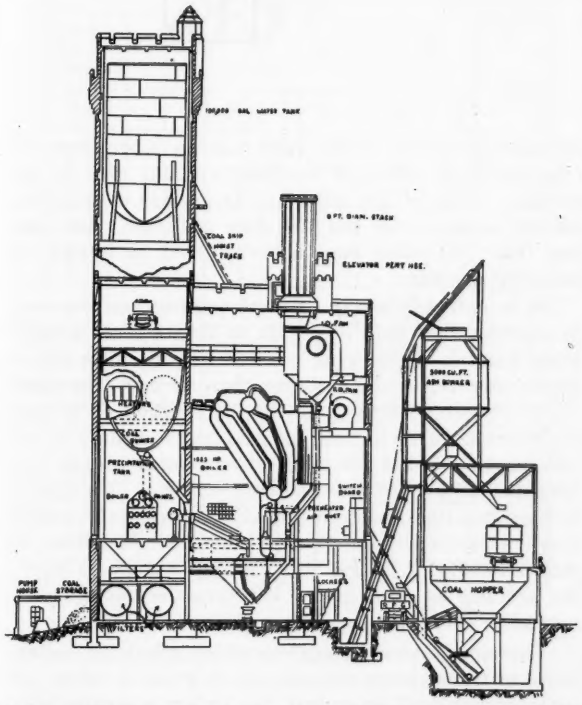


FIG. 3. CROSS SECTION OF LONGWORTH STEAM STATION

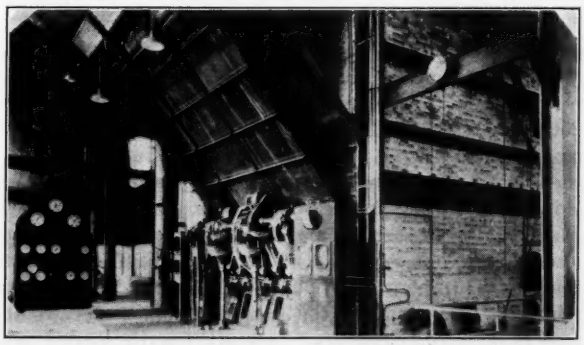


FIG. 4. THE FIRING AISLE. THE SECOND UNIT WILL BE INSTALLED IN THE FOREGROUND

a half mile from the plant. Above this panel are mounted feedwater and steam master gages and a telechron clock.

Connecting the boiler plant with the distribution system at Fourth and Ludlow Sts., are 2700 ft. of 16-in. pipe. At this point there is installed an underground vault where a reducing valve is installed to lower the pressure to 90 lb. ga. for the medium pressure system. Steam is also bled into the low-pressure system, through a motor-operated valve, controlled from the boiler plant. The line is welded throughout and has corrugated copper expansion joints. The insulation consists of two inches of Carey Multiply with a 30-lb. fiber rock jacket. The pipe is installed in a conduit made up of a concrete slab for the bottom, terra cotta hollow tile sides with a reënforced concrete top.

Careful consideration was given to the installation of high-pressure boiler equipment with a suitable non-condensing turbine to supply exhaust steam to the steam system; however, the load factor of the heating system requirements would permit the operation of the turbine only five months a year. With this limited operation, the return on the added investment was not sufficient to cover the fixed charges.

In designing this plant, simplicity of operation and reliability of service were the foremost considerations. On account of the very low load factor of the heating system, the cost of the plant and labor required for operation were held at a minimum, with due consideration of satisfactory service.

A.S.M.E. Nominates Officers

NOMINATIONS for officers of The American Society of Mechanical Engineers for 1932 were announced at a recent meeting of the nominating committee held at Birmingham, Ala., during the semi-annual meeting. Election will be held by letter ballot of the entire membership, closing on September 22, 1931.

Nominees as presented by the regular nominating committee of the society are:

President—Conrad N. Lauer, president, Philadelphia Gas Works, Philadelphia, Pa.

Vice-Presidents—Robert M. Gates, vice-president, Superheater Co., New York, N. Y.; Charles M. Allen, professor of Hydraulic Engineering, Worcester Polytechnic Institute, Worcester, Mass.; Fred H. Dorner, mechanical engineer, Milwaukee, Wis.; William B. Gregory, professor of Experimental Engineering, Tulane University, New Orleans, La.

Managers—Alexander J. Dickie, editor, Pacific Marine Review, San Francisco, Calif.; Eugene W. O'Brien, editor, Southern Power Journal, Atlanta, Ga.; Harry R. Westcott, president, Westcott & Mapes, Inc., New Haven, Conn.

Delegates, American Engineering Council—Conrad N. Lauer, Philadelphia; Paul Doty, St. Paul; R. E. Flanders, Springfield, Vt.; C. E. Ferris, Knoxville; L. P. Alford, New York City; J. H. Lawrence, New York City; R. C. Marshall, Jr., Chicago; A. A. Potter, Lafayette, Ind.; W. H. Trask, Jr., Salt Lake City; E. C. Hutchinson, New York City.

NEW ORDERS booked during the fourth quarter of 1930 as reported to the Bureau of Census, Department of Commerce, by 81 manufacturers of electrical goods were $195,546,657 as compared with $217,818,078 for the third quarter of 1930 and $288,696,415 for the fourth quarter of 1929. These totals include motors, storage batteries, domestic appliances and industrial equipment and are presented, not as a complete statement of the industry, but are sufficiently representative to indicate the trend, according to the Bureau of the Census.

VELOCITIES in pump suction lines for viscous liquids should be lower than for water. For oil they should be between 5 and 10 ft. per second whereas they may run up to almost double that for cold water.

SIMPLIFIED VOLTAGE DROP CALCULATIONS

By F. C. De Weese

Assistant Engineer
Carolina Power & Light Co.

Voltage drop is a subject with which every electrical man is concerned. In this article, the author discusses this subject from an entirely practical viewpoint. He shows how, by means of short cuts and simplified methods, it is possible to obtain practical results in the shortest possible time.

WHEN VOLTAGE is impressed on an electrical circuit and current begins to flow, due to the impedance to such flow, there is a difference in voltage between any two points along the circuit. This difference in voltage is what we call "Voltage Drop." This is an old subject but is of vital interest to anybody engaged in electrical engineering. In this article, it is not the purpose to discuss the theoretical aspects of the subject but rather to consider "short cut" and simplified methods of making voltage drop calculations.

In considering these methods, it should be understood that the same methods cannot be applied to all problems. An equation which will give accurate results on short lines may not give accurate results for the solution of long lines, due to the fact that on short lines the capacitance or effect of charging current may be neglected. Lines of 100 miles and larger are usually considered as long lines but this does not imply that lines less than 100 miles may be considered as having no charging current.

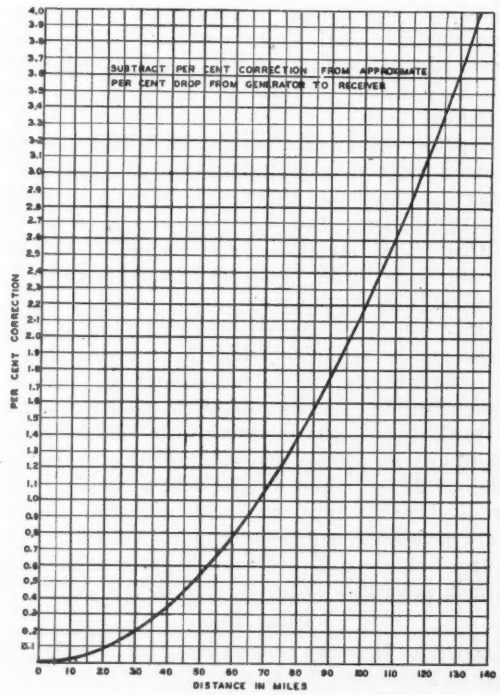

SUBTRACT PER CENT CORRECTION FROM APPROXIMATE PER CENT DROP FROM GENERATOR TO RECEIVER
PER CENT CORRECTION
DISTANCE IN MILES
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140

FIG. 1. CORRECTION CURVE USED IN VOLTAGE DROP CALCULATIONS

It is well within the limit of engineering accuracy, to consider that lines of 50 mi. in length have a negligible amount of charging current. It is quite appreciable, however, in lines longer than 50 mi. The effect of the charging current, on the distribution of voltage, is proportional to the voltage and to the square of the line length. It has the effect of causing a voltage rise, from the supply towards the receiving end of a circuit, in unloaded lines, while it serves to decrease the voltage drop in loaded lines. By applying the correction, as shown by Fig. 1, which is a distance correction curve, the method as here given, will produce results of a negligible error, for lines up to 150 mi. in length.

There are several conditions which affect the voltage drop, in transmission circuits, which must be taken into consideration and accounted for, before a correct solution to any problem can be made. These are such as: Kind of material of which the conductor is composed; spacing of conductors; power factor of the load; frequency of the power system; and length of the circuit.

From a voltage drop standpoint, there is little to be gained by using conductors larger than about 4/0 or 250,000 c.m. This is due to the fact that in the larger sizes, the inductive reactance decreases in very small increments, from one size to the next larger size. The skin effect, at 60 cycles, in usually large conductors becomes quite important and increases with increasing sizes. When the desired load cannot be handled with a reasonable drop, it is usually better practice either to increase the voltage of the supply or split the circuit into parallel combinations. In short, heavily loaded circuits, the voltage drop is usually not the limiting factor, but the heating effect of the current. When dealing with circuits of this nature, the heating factor, or allowable current carrying capacity of the conductor, must be taken into consideration. The circuit should be designed so that the current density will be reasonably low. Otherwise, with a negligible voltage drop, the circuit may be overloaded. This may not only overheat the conductor, but the power loss may be excessive, especially if the load factor is high.

Most problems coming up for consideration are proposed extensions to an existing system. In practically all such cases, the question of voltage drop enters into the proposition. Usually about all the information given to the designing engineer is the size of the load,

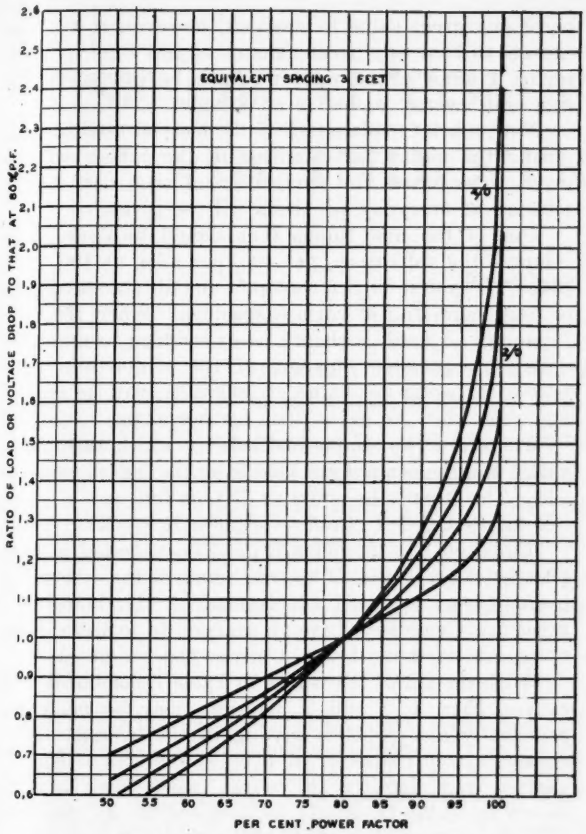


FIG. 2. CURVES USED IN VOLTAGE DROP CALCULATIONS

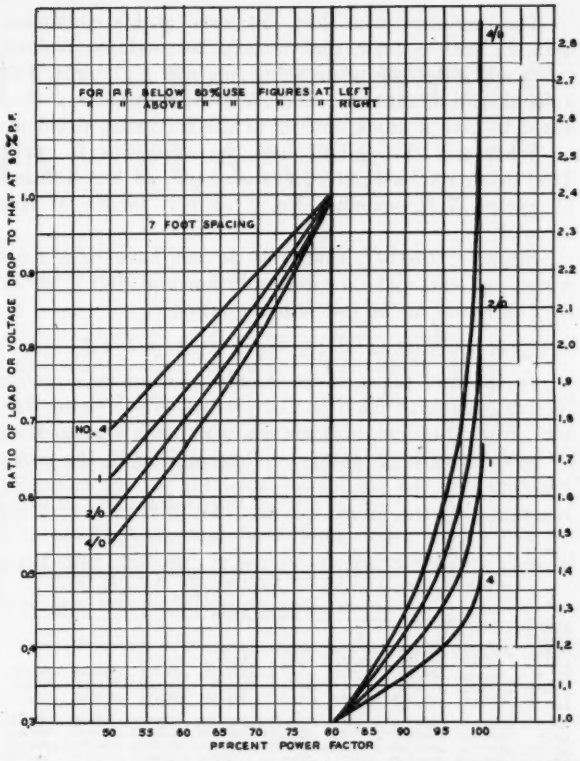

FOR P.F. BELOW 80% USE FIGURES AT LEFT
" " ABOVE " " " " RIGHT
7 FOOT SPACING
NO. 4
1
2/0
4/0
RATIO OF LOAD OR VOLTAGE DROP TO THAT AT 80% P.F.
PERCENT POWER FACTOR

FIG. 3. CURVES USED IN VOLTAGE DROP CALCULATIONS

either in kilowatts or horsepower and the location of the proposed load. From this information, the engineer, and rightly so, is expected to work out a practical solution, both from an engineering and economical standpoint. In a large number of proposed extensions, there are several conditions which must be investigated, before an intelligent and correct solution can be made, such as size of conductor on the line from which the extension is to be made; the load, or loads, being supplied from the existing line; voltage drop in the existing line, from source of supply to present loads; substation transformer capacity, etc. After these questions have been settled, the engineer is ready to proceed with the design of the extension itself.

When the term "voltage drop" is used, it is generally understood to mean the drop, in per cent, of the receiving end voltage. It is advisable to consider the receiving end conditions as being fixed, unless it is definitely known just what the sending end conditions are, which is rarely ever the case. Unless the voltage, current and power factor, at the sending end, are all known, the calculations for determining the receiver voltage, becomes quite complicated. On the other hand, if only the sending end voltage is known, it is usually advisable, to assume a receiving end voltage. (It is always known, within very close limits, just what this should be.) Then assume a certain size conductor and compute the voltage drop in the proposed line. This should require only two or three trials, when you should hit very close to the sending end condition, which will require only a few minutes.

There is still another point, which it would be well to keep in mind; that is, be reasonably accurate, but do not strive for extreme accuracy. In the final analysis, the only reason for making the calculation is to determine whether a certain size conductor, at a given line voltage, will carry the load, the desired distance, with a certain allowable voltage drop. It is usually good engineering and operating practice to design transmission lines such that the voltage drop, with an assumed maximum load, will not exceed about 8 per cent drop. This will give you a line that will take care of about 20 per cent more load than was originally anticipated, with not to exceed a drop of 10 per cent. This is about the maximum drop, if adequate service is to be maintained.

In designing transmission lines, it is not ordinarily the practice to consider the voltage drop through the transformers, at either end of the line, as transformers are provided with ratio taps, by which abnormal drop in voltage is compensated for.

TABLE I. VOLTS DROP PER KW. PER MILE AT 100 V., 3-PHASE, 60 CYCLES, 80 PER CENT P.F.

SIZE COND.		SPACING IN FEET 1	2	3	4	5	7	9	11	13	15
#8	Sol	41.055	41.570	41.864	42.088	42.254					
#6	"	27.014	27.579	27.904	28.150	28.354	28.619				
#4	"	18.373	18.976	19.325	19.585	19.782	20.075	20.303	20.480		
#4	Str	18.621	19.222	19.578	19.830	20.027	20.324	20.546	20.729	20.876	21.007
#2	"	13.126	13.748	14.124	14.386	14.592	14.903	15.138	15.325	15.480	16.613
#1	"	11.194	11.831	12.207	12.484	12.692	12.996	13.233	13.424	13.582	13.718
1/0	"	9.651	10.295	10.673	10.944	11.156	11.473	11.712	11.902	12.062	12.199
2/0	"	8.408	9.057	9.442	9.715	9.926	10.249	10.492	10.686	10.844	10.982
3/0	"	7.407	8.061	8.448	8.720	8.935	9.256	9.500	9.696	9.859	9.997
4/0	"	6.596	7.252	7.638	7.916	8.129	8.455	8.699	8.896	9.055	9.196
250	MCM	6.050	6.708	7.097	7.372	7.588	7.916	8.157	8.354	8.518	8.657
300	"	5.586	6.245	6.652	7.011	7.132	7.453	7.698	7.895	8.056	8.196
350	"	5.248	5.903	6.322	6.552	6.787	7.112	7.347	7.556	7.720	7.860
400	"	4.976	6.641	6.089	6.308	6.525	6.851	7.097	7.292	7.456	7.371
450	"	4.750	5.412	5.802	6.079	6.296	6.626	6.869	7.066	7.231	7.371
500	"	4.576	5.238	5.629	5.908	6.123	6.453	6.710	6.893	7.058	7.199

The engineer, who does not have at his command, data, in such a form that it may be used for making quick and fairly accurate solutions, will find himself at a decided disadvantage. For example, suppose you were asked to give a quick answer to the following problem:

What will the voltage drop be, in a line to carry 1250 kv-a., 1000 kw., at 80 per cent p.f., 22 kv., 3-phase, 60 cycles, 5 ft. spacing, No. 1 copper, length of line 20 mi.?

Suppose, further, that you do not have data from which you can make a quick solution and find it necessary to resort to the following equation:

$$E_{sn} = \sqrt{(E_{rn}Cos\theta + IR)^2 + (E_{rn}Sin\theta + IX)} \qquad (1)$$

In the first place, there is only one known quantity in this equation. That is $Cos\theta$, which is the power factor. For all others, it is necessary to make a calculation or refer to various tables, for determining R, the ohmic resistance of the conductor, also, for X, the inductive reactance, at the given spacing. Of course, if you are familiar with trigonometrical functions, you know that $Sin\theta$, for 80 per cent p.f. is 0.6. E_{rn}, the receiving end voltage to neutral, is equal to $22{,}000/\sqrt{3}$. Then I, the current in amperes, is computed as follows:

$$I = \frac{\text{kv-a.}}{3 \times E_{rn}} \qquad (2)$$

After all of the values, to be substituted in equation (1) have been determined, you are ready to solve for E_{sn}, the supply end voltage to neutral. This is all very simple, but the important thing about it is, that it requires a considerable amount of time. Even then, you are not sure of the result and more time is required for checking.

It is not an uncommon thing for an engineer, working for a utility, to be called upon many times in the run of a day's work, to solve voltage drop problems. In order to be able to make rapid and accurate solutions, in problems of this nature, I have developed what I believe to be the shortest, most accurate and most widely applicable method in use. These short cut methods require an enormous amount of calculations and tabulations before a sufficient amount of data to be of any great value is obtained; however, if any one expects to have any great amount of this kind of work to do, I know of no way in which he can spend his time and energy to better advantage.

TABLE II. PER CENT VOLTS DROP PER KW. PER MILE, 3-PHASE, 60 CYCLES, 80 PER CENT P.F., 11,000 V.

SIZE COND.	11,000 Volts 1	2	3	4	5	7	9	11
#8 Sol	.0033393	.0035436	.0035460	.0035478	.0035492			
#6 "	.0023383	.0023279	.0023306	.0023326	.0023342	.0023365		
#4 "	.0015181	.0015586	.0015597	.0015619	.0015236	.0015659	.0015678	.0015693
#2 Str	.0011085	.0011136	.0011167	.0011169	.0011206	.0011252	.0011251	.0011266
#1 "	.0009251	.0009778	.0010008	.0010025	.0010048	.0010074	.0010094	.0010109
1/0 "	.0007926	.0008508	.0008821	.0009045	.0009220	.0009482	.0009679	.0009836
2/0 "	.0006949	.0007485	.0007805	.0008029	.0008203	.0008470	.0008671	.0008840
3/0 "	.0006181	.0006568	.0006962	.0007207	.0007394	.0007650	.0007851	.0008013
4/0 "	.0005451	.0005995	.0006312	.0006542	.0006718	.0006987	.0007189	.0007352
250 MCM	.0005000	.0005544	.0005865	.0006905	.0006271	.0006542	.0006741	.0006904
300 "	.0004617	.0005161	.0005481	.0005712	.0005894	.0006160	.0006362	.0006525
350 "	.0004347	.0004876	.0005225	.0005415	.0005609	.0005876	.0006072	.0006245
400 "	.0004155	.0004662	.0004963	.0005213	.0005393	.0005662	.0005865	.0006026
450 "	.0003926	.0004473	.0004795	.0005034	.0005203	.0005476	.0005676	.0005840
500 "	.0003782	.0004329	.0004652	.0004865	.0005060	.0005335	.0005545	.0005697

SIZE COND.	3	4	5 66,000 VOLTS	9	11	13
#2 Str	.00003213	.00003303	.00003350	.00003421	.00003475	.00003518	.00003554
#1 "	.00002802	.00002848	.00002911	.00002983	.00003036	.00003082	.00003118
1/0 "	.00002450	.00002512	.00002561	.00002634	.00002689	.00002732	.00002769
2/0 "	.00002166	.00002239	.00002279	.00002353	.00002409	.00002455	.00002489
3/0 "	.00001939	.00002003	.00002051	.00002125	.00002181	.00002226	.00002263
4/0 "	.00001755	.00001857	.00001866	.00001941	.00001997	.00002042	.00002079
250 MCM	.00001629	.00001692	.00001742	.00001817	.00001873	.00001918	.00001955
300 "	.00001525	.00001589	.00001637	.00001711	.00001767	.00001812	.00001849
350 "	.00001451	.00001504	.00001558	.00001633	.00001687	.00001735	.00001772
400 "	.00001384	.00001448	.00001498	.00001573	.00001629	.00001674	.00001712
450 "	.00001333	.00001396	.00001445	.00001521	.00001577	.00001622	.00001660
500 "	.00001292	.00001356	.00001406	.00001481	.00001540	.00001582	.00001620

Now, a brief explanation of the method used in computing the values, as compiled in the tables, will be given, after which the application of such data to the solution of everyday problems will be given.

One of the first things that should be done, is to compute the volts drop, per kw., per mile, at 100 v., 3-phase, 60 cycles, 80 per cent p.f., for all standard sizes of conductors and at various spacings. When the term "spacing" is used, it should be understood to mean the delta, or equivalent spacing of the conductors. The reason for using the value of 100 volts, will be readily apparent when we get a little farther along.

There are two simple methods by which these table values may be computed. One is by the use of equation (1). The other is by equation (3), as follows:

$$E_{sn} = E_{rn} + I\ (Cos\theta - jSin\theta)\ (R + jX) \qquad (3)$$

Equation (3), as you will note, is expressed in complex notation. This, of course, involves the j term. I prefer to use equation (3) instead of (1), however, a great many engineers have an aversion to complex quantities, and to those, I would advise the use of (1).

With the aid of the values in Table I, combined with curves, Figs. 1, 2 and 3, solutions may be made for practically any problem arising in the average transmission system; however, if it is desired still to further shorten and simplify the work, tables, such as that shown by Table II, should be compiled for all standard voltages and spacings. Table II, as you will note, covers only 11,000 and 66,000 v.

In order to compile the values, such as shown in Table II, it is necessary to use values in Table I. As the values in Table I are volts drop, per kw., at 100 v., if we drop two places from 11,000, leaving 110 and square this, making 12,100 and divide this into any of the values in Table I, we shall have a figure that will represent the per cent volts drop, per kw., at 11,000 v. Following the same procedure, for other voltages, tables may be compiled for any desired voltage. If now we multiply kw-m. (kilowatt-miles) by any value in Table II, the product will be the volts drop, directly in per cent, for the given problem.

Many problems are encountered where there is more than one load being served from the same line and at different points along the line. Problems of this kind, with the aid of the tabulated values and curves, are just as readily handled and with but little more work than that required for a line serving a single load.

As you have no doubt noted, all of the previous work has been based on 80 per cent power factor and 60 cycles. By the use of the curves, Figs. 2 and 3, the voltage drop can readily be determined at other power factors; or the load at any other power factor, within reasonable limits, may be determined, with the same drop as at 80 per cent. There is also quite a number of 25-cycle systems and also some 50-cycle systems over the country; but, again, we do not need to worry, as lines of other frequencies may also be handled. For example, if the line in question is 25 cycles, 75 mi. long. Its equivalent 60-cycle length is $25/60 \times 75 = 31.25$ mi. Treat the problem as 31.25 mi., of 60 cycle line, results will be correct for a 75-mi., 25-cycle line.

USE OF AUTOMATIC REGULATORS IN INDUSTRIAL PLANTS

By J. H. ASHBAUGH
Westinghouse Elec. & Mfg. Co.

AUTOMATIC regulators are well known in generating stations. Their use in the Industries are not so well known but progress in the field has been rapid in the past few years with the result that there is available a number of different regulators having wide fields of application. In the article which is an abstract of a paper presented by Mr. Ashbaugh before a convention of the American Institute of Electric Engineers in New York, the fundamental theory of all regulators is explained and their application shown. Any regulator design can usually be used for many different applications.

AUTOMATIC REGULATORS have been used for years in generating station practice. The use of regulators in industry is not so well known but the progress in this field has been rapid in the past few years with the result that there is available a number of different regulators having wide fields of application. In general, the factors to be controlled are voltage, current, power factor, load, speed, tension, pressure and temperature.

There are three different classes of automatic regulators, mechanical, hydraulic and electrical. The first regulators were largely mechanical, such as water wheel and reciprocating engine governors. These were supplanted by the hydraulic type and later electrical regulators made their appearance. The growth of regulators is a material one when the field for the use of the electric regulator is considered. Among the many important phases of regulation are the controlling of electric furnaces, thickness and moisture of paper, temperature of furnaces, accurate cutting of steel bars or sheets to specified lengths, d.c. motors having synchronous characteristics, turbine governors holding a definite load or steam pressure, and many similar problems.

In the design and application of regulators, many factors must be considered, such as the precision of regulation required, rate of departure from uniform values if unregulated, mechanical or hydraulic inertia of the system, etc. Where variations in unregulated quantities are slow and where detection of such variations can be made without appreciable lapse of time, such regulation problems are usually simple and may not require anti-hunting means. Where changes are rapid, however, the problem is more involved and anti-hunting means must be employed.

When any piece of apparatus is to be controlled automatically the problem can be separated into two parts, means for getting a measure of the quantity to be controlled and means to prevent what is commonly called hunting. The reactionary or anti-hunting means is the heart of the regulator.

The fundamental problem of anti-hunting is to remove the restoring force previous to reaching the normal or steady condition, thereby discounting the inertia of either the mechanical or electrical bodies. An analysis of the nature of this problem may be obtained by considering the application of forces necessary to move a

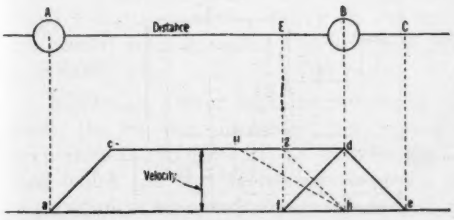
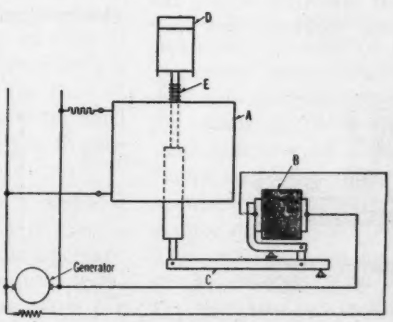


FIG. 1. DISTANCE AND VELOCITY CURVES



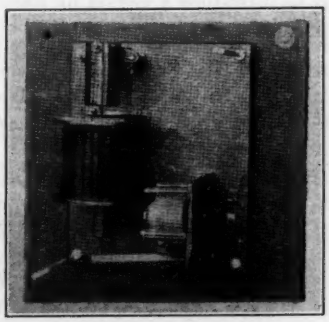


FIG. 2. D.C. CARBON PILE VOLTAGE REGULATOR

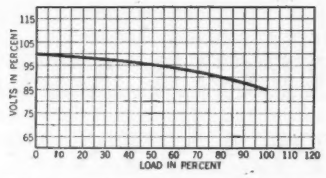


FIG. 3. DASHPOT RECALIBRATION CARBON PILE REGULATOR

body from its initial position A to its final position B, Fig. 1. Let the ordinates of the curve a c d e be velocity and abscissas time. For the sake of simplicity we will consider that it is permissible to represent distances by projecting points on the velocity diagram directly on the distance diagram A B. The application of an accelerating force will cause the velocity to increase continuously as indicated by *a c* in the velocity diagram. At the point *c* the accelerating force equals the propelling force, and the body travels along the line *c d* at a uniform rate. If the propelling force is removed at the point *d* it is obvious that it cannot stop instantly so the body will coast down along the line *d e*. If when it comes to rest, action is set up to return it to the point *d*, it will accelerate along the line *e d*, and when reaching *d*, the propelling force is again removed it will coast down along the line *d f*. When reaching the point *f*, reverse forces again come into play, the body will be carried to *e*. This results in oscillations called hunting, the body being continually carried backwards and forwards between the points *e* and *f*, it being impossible ever to stop at the point *d*.

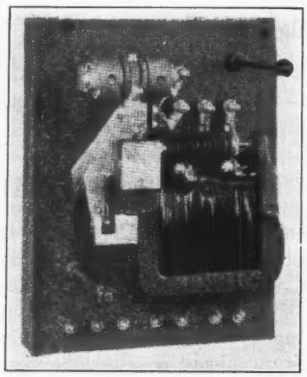


FIG. 4. CARBON CONTACT VOLTAGE REGULATOR

The only way such a device can be made to function is to introduce a region or zone of inactivity within the limits of which the quantity being regulated can vary without bringing into play any corrective forces and by making the motion so slow that the overshooting from *e* to *f* falls within the zone of inaction.

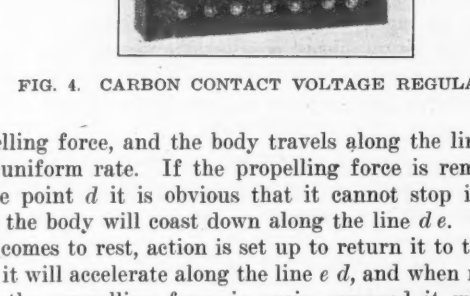


FIG. 5. CARBON CONTACT VOLTAGE REGULATOR

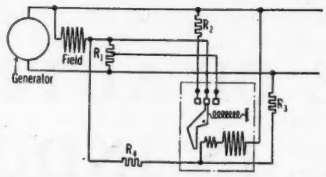


FIG. 6. DIAGRAM OF CARBON CONTACT REGULATOR

The water-wheel governor with which everyone is familiar is a typical example of the above fundamentals. The flyballs vary the gate opening by an oil relay system, however, a movement of the gates mechanically resets the oil relay system before the speed is normal by an amount depending on their speed of movement.

Voltage

Among the various types of voltage regulators available, the metallic contact vibrating type of voltage regulator is well known and no time will be given to its discussion except to state that it is the standard of comparison by which other regulators are judged.

Another type, the carbon pile type of voltage regulator, has been used for many years on low voltage. It has been refined as shown in Fig. 2 and applied on higher voltage being especially designed for industrial purposes. Coil A is energized from the source to be controlled and varies the pressure on a stack of carbon disks B through the lever C. The dashpot D is a graphite piston in a cadmium plated iron pot. The use of cast iron and graphite permits a wide variation in temperature with a minimum variation in damping. The spring E connects the dashpot to the lever. The action of the spring connected dashpot is to recalibrate the regulator when a movement of the lever is initiated by the control coil, the amount of the recalibration being a function of the lever travel. Curve, Fig. 3, is the voltage regulation which would result if the dashpot plunger were not free to move.

Carbon pile regulators for a.c. generators require more anti-hunting as the carbon pile is connected in the field of the exciter. This is obtained by the addition of another spring connected dashpot.

Vibrating Regulator, Industrial Type

A new vibrating contact regulator has been designed for industrial applications where a more sturdy regulator is essential. The magnetic system operates on the electro dynamic principle, as shown in Fig. 4 and 5.

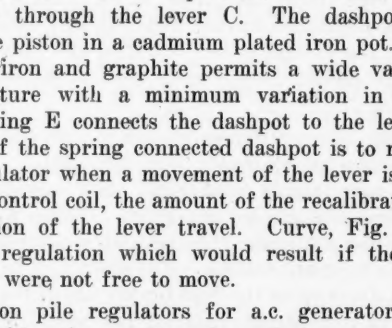


FIG. 7. LOAD REGULATOR ON D.C. MACHINE

The stationary coil produces a flux in the circular air gap c. The armature consisting of the movable coil b operates in this air gap and is completely surrounded by the flux from coil a. Thus when current flows in the movable coil a torque is produced which is opposed by the spring f.

This regulator can be applied as a voltage, current or speed regulator. Figure 6 shows how these contacts are used when the voltage of a generator is to be controlled. In order to change the field current the per cent time of contact engagements must vary. Since this cannot vary without producing a greater average contact pressure, the regulator will have an error from a permanently closed contact to an open one of approximately 1½ per cent.

Load Regulation

There are many places where load regulators are required such as in electrochemical processes where chemical reaction requires the applied electrical energy to be held within close limits or most any manufacturing concern purchasing all or part of its power. The

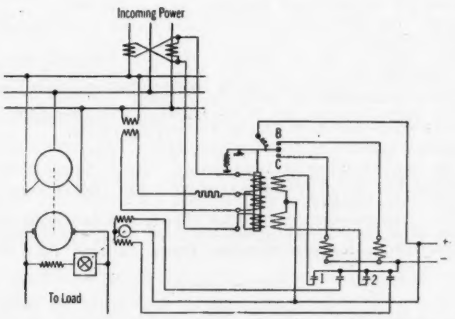


FIG. 8. PLANT LOAD REGULATOR ON D.C. MACHINES

regulation of load may, therefore, be divided into two classes, that which is necessary for specific processes of manufacture and that which is necessary to meet a given power contract. In the case of the former, it is usual to vary the excitation of a booster type rotary converter or a d.c. generator. In chemical plants or where the load variation is not too fluctuating, a rheostatic regulator is used as in Fig. 7. This is a contact making voltmeter which controls a motor-operated field rheostat. The wattmeter element is energized from either a shunt or interpoles of the machine. The spring A is adjustable so the value of the regulated load can be varied. The contacts B and C control secondary relays which operate the rheostat and also produce a reactionary means to prevent hunting. The auxiliary contacts 1 and 2 energize the anti-hunting winding D and E. The effect of this winding is to produce a torque which causes the main contacts to vibrate, the time of contact engagement depending on the amount the load has varied from normal. The practical effect is to give a variable speed to the rheostat motor.

Where all power used is purchased on a demand basis, the amount purchased can be varied (so as to keep close to the demand) by switching off unimportant load which can be interrupted for a few minutes without endangering production. The load regulator for switching on and off blocks of power is merely a contact

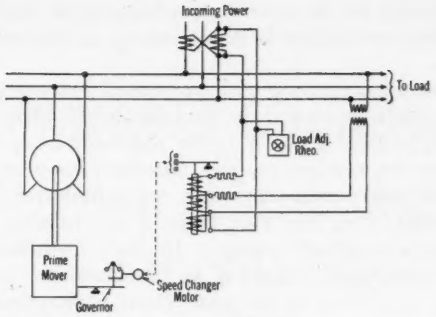


FIG. 9. PLANT LOAD REGULATOR SINGLE UNIT PRIME MOVER

making demand meter that switches the load off when the demand is somewhat under the power company's demand. This is again switched on when the demand period has passed. The type regulator used is similar to that of Fig. 7 but is connected as shown in Fig. 8.

Where the plant generates a portion of its power requirements and purchases the remainder, a saving in generated kilowatts can be effected by maintaining the purchased power constant. The load fluctuations would be taken on the plant's own turbines by varying the governor setting. If only one machine is to be varied the connections and equipment are as shown in Fig. 9. If more than one unit is to be controlled, it is desirable to use means whereby a predetermined load ratio will be maintained. This can be accomplished by using load regulators which can be adjusted on each turbine, Fig.

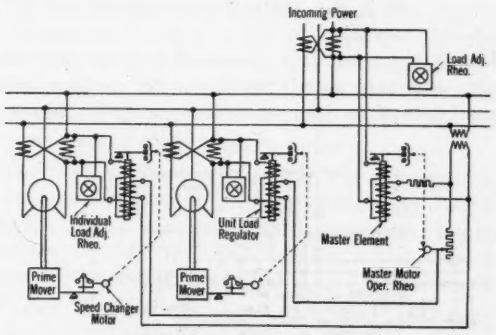


FIG. 10. PLANT LOAD REGULATOR MULTIPLE UNIT PRIME MOVER

10, and having the master element affect all individual regulators by the same amount.

Power Factor Control

In many instances, the power companies' contracts are based not only on the kilowatt demand but also on the power factor being maintained within certain limits. For this purpose power factor regulators can be used. By changing the connections and counterweights, the load regulator of Fig. 8 can also be used as a power factor regulator. The only difference between the load regulator and a power factor regulator is the method of connecting the transformers; that is the phase relation. This regulator can be made to work on the excitation of the generator and by means of an auto-transformer the regulated power factor can be adjusted. Figure 11 shows how this adjustment can be accomplished. Briefly,

the regulator has its lever system balanced so that without current or voltage it would remain in neutral position.

In some installations with purchased power and part of the power generated in the customer's plant, it is desirable to have a power factor regulator in operation when the two systems are tied together; however, upon failure of the purchased power, or an isolation of the two system, it is desirable to have the isolated plant maintain a constant voltage. In such installations a voltage regulator is applied to the generator or synchronous condenser in the small plant as shown in Fig. 12. A power factor regulator element is connected in the lead coming in from the purchased power. The power factor element is then made to vary the voltage

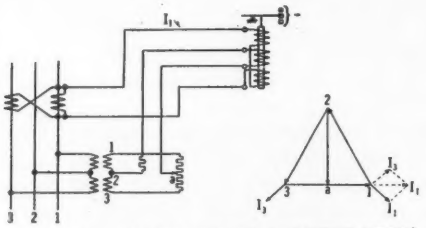


FIG. 11. POWER FACTOR REGULATOR

adjusting rheostat of the voltage regulator in order to maintain a constant power factor from the purchased power. If the synchronizing breaker opens, a pallet switch opens the circuit to the power factor regulator, thus removing this element leaving the voltage regulator in control, and it will maintain the voltage at any desired point thereafter.

Besides the regulators discussed in this article there are also available speed regulators for motors driving various types of equipment such as paper machines, rod

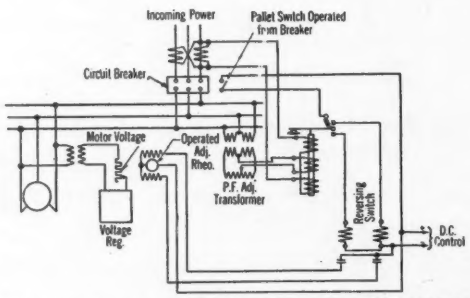


FIG. 12. POWER FACTOR CONTROL OF VOLTAGE REGULATOR

and strip mills, etc. For this purpose, the carbon pile type of regulator has proved successful.

The most recent trend in regulators design has been towards the use of electron tubes. They offer great possibilities in the elimination of moving parts and greater sensitivity.

STEAM AND ELECTRIC loads should never be compared on a pound and kilowatt-hour per day basis without knowing the daily or hour-by-hour load curves. One load might be heavy at a time when the other is light and the daily average would lead to wrong conclusions as to their relation.

Lubrication Engineering Meeting at State College on May 22

AT THE PENNSYLVANIA STATE COLLEGE, State College, Pa., on Friday, May 22, a lubrication engineering meeting will be held under the joint auspices of the Pennsylvania State College and the Lubrication Engineering Committee of the Petroleum Division—American Society of Mechanical Engineers. Meetings are to begin at 9:30 a. m. at Nittany Lion Inn.

PROGRAM

Presiding Officer: R. L. Sackett, Dean of Engineering, The Pennsylvania State College.

Lubricant Testing. By E. G. Boden, Engineer, and O. L. Maag, Oil Chemist, The Timken Roller Bearing Co., Canton, Ohio.

Bearing Design in the Light of Oil Film Pressure Investigations. By L. J. Bradford, Prof. of Machine Design, The Pennsylvania State College.

Fluid Film Lubrication as Applied to Railroad Journal Bearings. By F. O. Willhofft, Secy. & Gen. Mgr., Isothermos Corporation of America, New York, N. Y.

Oral Discussion of Lubrication of Railway Bearings. By M. E. McDonnell, Chief Chemist, Pennsylvania Railroad, Altoona, Pa.

Open Discussion.

12:30 p. m.—Luncheon.

2:00 p. m. Session, Nittany Lion Inn.

Presiding Officer: J. G. O'Neill, Chief Chemist, U. S. Naval Engineering Experiment Station, Annapolis, Md.

Symposium on Internal-Combustion-Engine Lubrication with Lubricants from:

Coastal Crudes. By A. Ludlow Clayden, Sun Oil Co., Philadelphia, Pa.

Pennsylvania Crudes. By C. M. Larson, Supervising Engineer, Sinclair Refining Co., New York, N. Y.

Midcontinent Crudes. By E. R. Lederer, Vice-President, Texas Pacific Coal and Iron Co., Fort Worth, Texas.

Open Discussion.

6:00 p. m. Dinner, Nittany Lion Inn.

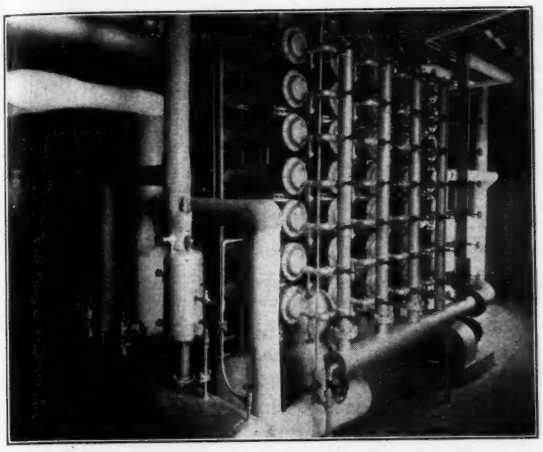
Evening bus for Tyrone leaves at 7:15. Taxis may be obtained for later trains.

Further information regarding transportation and hotel accommodations may be obtained from F. G. Hechler, chairman, Lubrication Engineering Meeting, State College, Pa.

PRELIMINARY EARNINGS of Northern States Power Co. for the 12 mo. ended December 31, 1930, show an increase in gross earnings amounting to $517,842 or 1.58 per cent and a decrease in net earnings of $181,259 or 1.08 per cent, compared with the previous 12 mo., according to John J. O'Brien, president, Byllesby Engineering and Management Corp. Reasons indicated for the increased operating expenses and decreased net earnings were poor water conditions which affected the company's hydroelectric plants.

Preliminary earnings of Oklahoma Gas and Electric Co. for the 12 mo. ended December 31, 1930, show an increase in gross earnings totaling $122,314 or 0.86 per cent, and an increase in net earnings of $40,907 or 0.61 per cent, compared with the previous 12 mo.

Preliminary earnings of Louisville Gas and Electric Co. (Delaware) and its subsidiaries for the 12 mo. ended December 31, 1930, show an increase in gross earnings of $228,289 or 2.20 per cent, while net earnings increased $88,789 or 1.66 per cent, compared with the previous 12 mo. The preliminary information available indicates earnings of the company were affected by the general business depression and severe drouth conditions, for during eleven months of 1930 beginning in February the territory served by this company suffered the worst drouth ever experienced which seriously reduced the amount of power available at the Ohio Falls hydroelectric station. Electric energy output, however, increased 6.09 per cent over 1929 to a total of 348,598,452 kw-hr.



Ammonia Condensers
Their Care and Operation

By C. T. BAKER
Consulting Engineer
Atlanta, Ga.

DOUBTLESS THE AMMONIA condensers in many ice making and refrigerating plants are responsible for more causes of reduced plant capacity and abnormal power costs than is generally supposed. In far too many such plants, this equipment is treated more or less with indifference and neglect, both as regards operation and maintenance and in consequence of this, the owner is heavily penalized in more ways than one.

Refrigerating engineers, refrigerating machinery manufacturers and others have called attention for years to the necessity for proper attention to the "high-side" of the plant and have religiously emphasized the evils which follow in the wake of neglect of this vital apparatus but as yet we are a long way from the possible goal in hundreds of installations.

The writer is fully cognizant of the fact that in this article will be found nothing that has not been said many times before; however, we are often able to effect improvement in plant operation by a reperusal of first principles and of our early teachings which by the way, offers the writer at least one excuse for that which follows:

Classification of Condenser

Ammonia condensers are properly classified as atmospheric, double pipe, or concentric-tube, shell and tube, both vertical and horizontal, and bleeder type. Other types are in use, of course, but the foregoing represents present-day practice to a pronounced degree.

As is well known, the function of these and all other types of condensers is to furnish a means of removing heat from ammonia gas, both sensible and latent, and to convert such gas to a liquid.

If we could now say that when we had accomplished this change of state in ammonia (gas to liquid) we had fulfilled the requirements of condensation in their entirety, we could at once dismiss without much further consideration, the entire subject of ejecting heat at the higher temperature levels and consider the problem as satisfactorily solved. Such is not the case, however, since quite a number of other related problems are at hand that call for attention, some of which are discussed in this article.

If the proper start is to be made looking to the attainment of maximum economic results in condenser operation, the first steps should be in the direction of proper selection of condensers in order that the requirements of the local conditions surrounding the installation may be economically met.

In the early days of the ice industry, the atmospheric type ammonia condenser predominated and was usually built up in coil sections of from 12 to 24 pipes high and from 18 to 20 ft. in length, using 2-in. diameter pipe, connected at the ends with close center return bends.

Such condensers are still used and are found very satisfactory where properly cared for.

The double-pipe condenser likewise represents a type of comparatively early origin and one that is still successfully and widely used in certain installations, particularly where it is necessary to contain the condensing water in a closed circuit until the run off reaches the sewer or cooling tower or spray pond.

The flooded condenser in both the atmospheric and double pipe type made its appearance some 20 yr. ago at which time it was proclaimed by many as the greatest discovery in condenser practice but which, due to its inherent shortcomings, was not long for this world.

Today the vertical, single-pass, shell and tube and the horizontal, multipass, shell and tube condensers are quite popular and are rapidly replacing other types.

The bleeder type condenser also made quite a bid for favor a few years ago but this design likewise gradually faded from condenser practice due to certain features that made it undesirable as a universal apparatus.

Many of the failures of ammonia-condensers to function at maximum capacity and efficiency, however, may properly be laid at the door of ignorance, indifference and neglect on the part of the owners and operators.

Some of these are named as follows: condensers too small for the requirements, insufficient condensing water, condensing water insufficiently cooled where conditions make it necessary to recirculate such water for reuse, accumulation of air and other noncondensable gases in the ammonia system, neglect to clean condensers properly at regular intervals, wastage of water due to improper distribution in case of the atmospheric type, absence of thermometers on liquid outlet and on condensing water inlet and outlet connections, improper

erection and poorly arranged piping connections, particularly liquid lines between condensers and liquid receiver, improper location of condensers, all of which may be eliminated if there is a determination on the part of responsible parties to remedy a condition that is known to be clearly and definitely wrong.

To begin with, and assuming a new installation to be made, careful consideration should obviously be given to the type of condenser that will best fit the local requirements, all things considered, and when selected see to it that proper foundations or supports are provided in order that there will be no settling or other disturbance after erection.

Do not so locate double pipe condensers, for instance, that there is no room for tube cleaning and tube renewals. Such condensers are often so placed with reference to building walls that cleaning is impossible.

Recently the writer investigated a plant where such conditions prevailed and where condensing pressures of from 215 to 230 lb. were common during the summer months and discovered upon removing some of the return bends that the inner tubes were coated with over a quarter of an inch of heat-resisting deposit.

The plant was about 5 yr. old and due to the location of the double pipe condensers between two brick walls it was absolutely impossible to scrape the tubes, in fact no cleaning of tubes had been possible since the plant was first built.

These condensers will be located outside the building this winter where they may be properly cared for, however, power has been wasted for nearly 5 years at a cost of 1¼ cents per kw-hr.

In the case of the vertical shell and tube or horizontal shell and tube condenser, the same consideration must be given to the question of room for proper cleaning of tubes. To overlook this is to invite trouble as well as abnormal power costs.

Regardless of the type of condensers used, do not neglect to keep the water surfaces clean and the ammonia surfaces as free of oil as possible.

Proper Liquid Drain

In all too many instances, too small drain lines are installed to drain the liquid from the condensers to the liquid receiver. Such pipe connections should be as short and direct as possible and of ample cross section to insure rapid drainage.

Likewise, the liquid line must be free of traps and should preferably slope from the liquid outlet of the condensers toward the receiver.

When gas is converted to liquid in the condenser, it should be allowed to drain quickly to the receiver. Restricted liquid drain lines result in higher condensing pressures and also reduced condenser capacity where the condensers are always partly filled with liquid near the bottom since the presence of liquid, in any quantities, reduces the effective condensing surface.

In many cases, the liquid inlet connection at the receiver is ¾ in. or even less in the smaller installations. Such small openings in the receiver shell absolutely prevent proper drainage. In the writer's opinion, no receiver except very small ones should have less than a one-inch diameter opening.

Water Supply

Always provide the condensers with the lowest possible condensing water temperature as well as an ample supply of such water. The lower the temperature the less the amount of water required per ton of machine capacity and the lower the pumping costs.

Proper distribution of the condensing water after delivery to the condensers is likewise essential in order that all condensing surfaces may be properly supplied. This is especially true of the atmospheric and the open, vertical shell and tube condenser.

In the case of the latter type, distribution ferrule or other attachments are required to effect an even and equal supply of water to all tubes.

With the atmospheric type of any design, the space between the individual pipes should be bridged, or at least 50 per cent bridged with thin metal strips so as to form a controlled path for the water to pass from the top to the bottom of the coils without splashing off and going to waste insofar as taking up heat is concerned.

The amount of condensing water required for any given installation will depend, of course, upon the initial water temperature which will be different for different localities and may vary from 50 to 85 deg. in the case of recirculated water, which means that the quantities per ton may easily range anywhere from 1¼ to 5 gal. per ton of developed refrigerating capacity.

Non-Condensable Gases

A great deal of abnormal condensing pressure troubles result from the presence of air in the ammonia system. Air and other gases that are not condensed occupy a part of the space in the system and prevent the pressure drop in the condensers that would obtain were the system free of such gases.

Hand purging of condensers is uncertain and wasteful. This is an operation that should be performed by automatic purgers of which there are several on the market and which will generally pay for themselves within a year after their installation.

With a given quantity and temperature condensing water, it is easily possible with clean condensers and the system free of air to realize very closely, theoretically condensing pressures. Unless such values are approximated, power is being wasted and capacity sacrificed.

Thermometers

No condenser installation is complete without the proper complement of thermometers as a guide to operating economies. A thermometer should be located on the condensing water inlet and outlet to the condensers so as to denote the temperature range which, among other things, will indicate when cleaning is necessary.

A thermometer on the liquid ammonia outlet is also necessary, since it will indicate how closely the liquid temperature approaches the run-off water temperature and whether or not there is subcooling due to the presence of air in the system.

Cheap thermometers, however, should be avoided. Thermometers made only by reputable concerns who guarantee very close accuracy should be employed.

The Sun's Heat

Frequently it is possible to improve condenser operation by providing suitable protection against sunshine

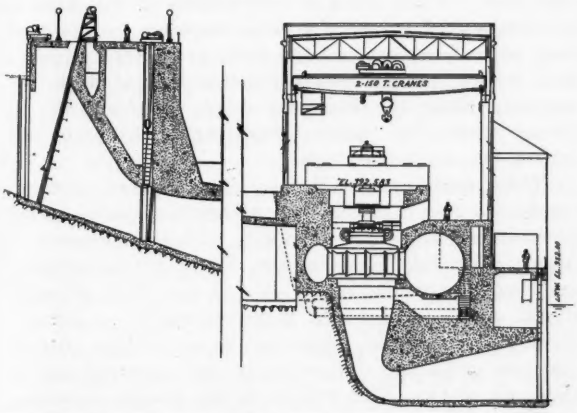
where condensers are located in the open. It is preferable that sun breaks be provided so as to prevent the direct rays of the sun striking the condensers as by this method much heat is prevented from reaching them and this will operate to insure lower pressures.

The author has attempted to outline in the foregoing treatment of condensers practical methods of condenser management and operation which if correctly interpreted and followed will result in much greater capacity and economy than is found in many installations.

Spier Falls Now Has Largest Water Wheel Unit

SINGLE UNIT WITH RUNNER DIAMETER OF 19 FT. 6 IN. DEVELOPS 57,000 HP. AT FULL GATE, 81 FT. HEAD

WORK RECENTLY completed at the Spier Falls Plant of the New York Power and Light Corp., on the Hudson River about 15 mi. west of Glens Falls, N. Y., consisted of enlarging and extending the old forebay, the building of a new intake for two large units,



CROSS-SECTION THROUGH NEW UNIT AT SPIER FALLS ADDITION

building a penstock and power house for one unit, excavating the tailrace so as to carry the increased flow of water without excessive loss of head and installing a new unit, stated to be the largest in physical dimensions yet installed.

Prior to the beginning of the work, model tests were made of the forebay and intake to determine the economical size and design. It is estimated that about $50,000 was saved by the knowledge gained from the tests.

Following are data on the new water wheel:

Capacity at full gate	7100 c.f.s.
Horsepower at 81 ft. head	52,000 at best gate; 57,000 at full gate
Diameter of runner	19 ft. 6 in.
Weight of runner	140 t.
Shaft 39 in. dia.—weight	38 t.
Total weight of wheel and settings	825 t.

This runner was cast and shipped in three sections, each section weighing 40 t. The shrink rings for the runner, because of their large diameter, were shipped from Newport News to Albany by steamship and from Albany to Fort Edward by barge and thence to the site by truck.

Scroll case is of steel plate, entrance diameter 26 ft. It is allowed to expand under water pressure by a covering of compressible material placed between the steel plate and the concrete.

The generator is stated to be the largest in diameter yet built. It is of umbrella type construction. The data follow:

	Type	Form	Poles	Capacity	R.P.M.	Volts
Generator	A.T.B.	W	88	47,000 KVA	81.8	13,800
Main Exciter	E.V.F.	A	14	264	81.8	250
Aux. Exciter	M.P.	A	10	6	81.8	250
Diameter of rotor					31 ft.	4½ in.
Diameter of stator					37 ft.	0 in.
Diameter of air duct					43 ft.	0 in.
Weight of rotor						223 t.
Height from bottom of draft tube to top of exciter					88 ft.	11¼ in.

The generator has an enclosed air cooling system, air being cooled by 12 water-cooled radiators set equidistantly around the stator. Total weight of the revolving parts of the water wheel is about 450 t.

Two 150-t. cranes are used in dismantling the unit, the two cranes being required to lift the generator rotor and one being required to lift the water wheel runner. Use of two cranes saved considerable height in the superstructure.

The three draft tube opening can be closed by steel curtains, each curtain 21 ft. high and 19 ft. 4 in. in the clear opening.

Penstock is of reënforced concrete 26 ft. inside diameter. The intake has four openings per unit, closed by four Broome type head gates 17 ft. 6 in. high and 12 ft. wide per unit. Individual hoists operate these gates with remote control on the main switchboard.

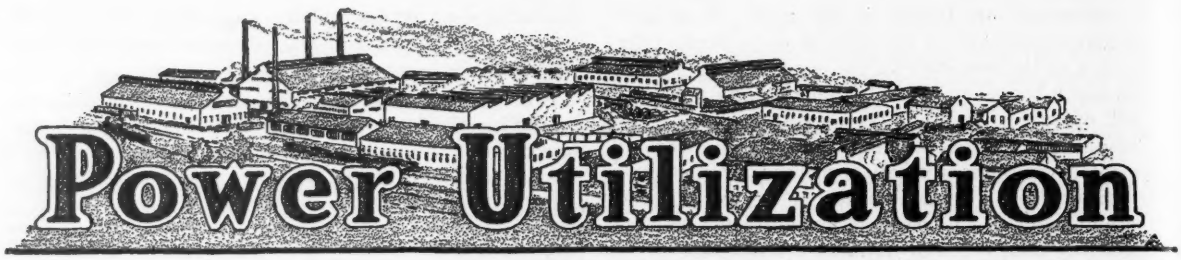
PRINCIPAL NEW EQUIPMENT AT SPIER FALLS ADDITION

Intake Steel Curtains and Hoist	Philips & Davies, Inc.
Welded Steel Racks, Rack Rake and Hoist	Newport News Shipbuilding & Dry Dock Co.
Head Gates—Broome Type	Philips & Davies, Inc.
Water Wheel	Newport News Shipbuilding & Dry Dock Co.
Generator	General Electric Co.
Powerhouse Crane—2 150-ton with 15-ton aux.	Whiting Corp.
Draft Tube Steel Curtains	Newport News Shipbuilding & Dry Dock Co.
Sump Pump—Deep Well Type	Worthington Pump & Machinery Corp.
Ice Sluice Gate—Drop Type	Treadwell Engineering Co.
Engineers and Designers	Parsons, Klapp, Brinckerhoff & Douglas
Contractors	Allied Engineers, Inc.

In place of stop logs in the intake, steel curtains are used, three curtains being necessary to close one intake opening. An ice sluice at the end of the forebay has a steel gate 14 ft. high and 8 ft. wide which opens by being lowered, thus permitting ice to be skimmed from the forebay without excessive loss of water.

During the construction of the new unit the spillway of the dam was also altered. Previously, 5 ft. 6 in. of flashboards were carried on steel pins but this arrangement was not efficient in the saving of water, so Tainter gates have been erected. The new arrangement consists of one 12 ft. long Tainter gate for logging and fifteen 27 ft. long Tainter gates for pond control up to 40,000 c.f.s. The remainder of the spillway consists of eleven 27-ft. spans of flashboards supported on needle beams. All gates and flashboards are 8 ft. high. The Tainter gates are operated by a traveling hoist and the needle beams are jacked loose by screw jacks.

With all gates open and flashboards out the spillway has a capacity of 100,000 c.f.s.



Inspection Routine for Electrical Equipment

RECORDS FOR EACH MACHINE AND RESPONSIBILITY FOR CONDITION ARE ESSENTIAL. BY A. I. GREENWOOD*

MODERN electrical equipment, being well made, will often give excellent service for a long period of time with little attention, yet sometimes a machine that has apparently been operating satisfactorily, will fail suddenly without warning. Why can this occur?

Electrical equipment differs somewhat from mechanical. In the mechanical part of a machine, wear or failure of any part will make itself known by a noticeable noise. Sometimes electrical equipment will give evidence of approaching failure by noise or by heat but many times a dangerous condition will exist which casual observation of the machine will detect. For this reason it is important that all electrical equipment should be inspected regularly and systematically.

This can be accomplished in many different ways. Whatever method is used, some system of records should be kept so that all equipment will be inspected at regular intervals. An additional advantage of records is that the performance of a given piece of apparatus will be known and, if at some future time, a change is made which should result in reduced maintenance cost, whether or not the saving desired has been accomplished, can be determined.

One method for maintenance of electrical equipment is to keep an accurate record for each piece. Probably, a card file is the most convenient method of doing this. Each time a given piece of apparatus is inspected a complete record is made of its condition and the work done upon it, so that by regularly inspecting these cards the person responsible for the proper maintenance of equipment can keep in touch with the condition of each item. When using a card system of this kind it is necessary, of course, for each workman to make out some sort of a record of the work done. Sometimes a card is used, having a blank for each item of work that might be done, the workman simply checking off the proper items, the record being transferred from this card to the permanent record.

These cards can be filed by future dates. For example, suppose a certain circuit breaker should be inspected once in three months. If this breaker is inspected on July 30th the card, Fig. 2, will be attached and record card filed under date of Oct. 30th, although it will probably be found more convenient to arrange these future dates by weeks instead of by days. In the example given all equipment to be inspected during the week of Oct. 30th will be in the record as needing that inspection. Some items will need inspection once a week, some once a month, some every three months and some, such as oil in distribution transformers, may require inspection only once a year.

*Chief Electrician, United Verde Copper Co.

MOTOR RECORD

UNITED VERDE COPPER CO. — SMELTER Frame # 856

H. P. 75 MAKE Westinghouse TYPE CW VOLTS 2200 SERIAL NO 1952923

LOCATION	TYPE DRIVE	DATE INSTALLED	DATE REMOVED	CAUSE	REPAIRS	DATE
#59 Conveyor	Belt	8-20-27	5-24-28	Burn out Stator	Complete rewind	6-4-28
#1 Symons	"	7-27-28	8-12-28	Stator Loose on Spider	on Stator	8-14-28
#1 Fan	"	8-16-28	9-4-28	on this drive	Temporary to replace C.S motor	
#1 Symons	"	7-22-29	10-18-29	Mechanical repairs	New dust guards	
#9 Symons	"	4-4-30		and Conduit box		

BEARINGS CHANGED

FRONT END TYPE Solid		PULLEY END TYPE Split		PEDESTAL TYPE		REMARKS
CAUSE	DATE	CAUSE	DATE	CAUSE	DATE	
		Low	5-4-28			
	Burned out (ore dust in bearing)		8-12-28			
	Burned out		8-31-28			
	Tight Belt					
	Burned out		9-7-28			
Scored Shaft	Improperly Filled					
New Shaft	9-24-28	New Shaft	9-24-28	(When new shaft was installed		
Low	11-12-29	Low	11-12-29	Pole dust guards were		
Burned out	6-18-30			added		
no oil.						

FIG. 1. RECORD SHEET FOR MOTOR TO SHOW LIFE HISTORY

INDIVIDUAL RESPONSIBILITY

It is self-evident that while the method just described will enable the person in charge to keep accurately informed of the condition of equipment, it has the disadvantage of requiring considerable clerical work. Another disadvantage is that most of the responsibility is placed directly on the department head or foreman and but little on the workman. A second method re-

Form 778 **Repaired Equipment** U. V. C. CO.

Date Repaired July - 30 - 1929

Equipment oil circuit Breaker

From B & Sw. House

Repairs Made New oils overhauled - Complete

Repaired by HANCOCK & WHIPPLE

Tested and Inspected by

FIG. 2. REPAIR CARD RECORD FOR CIRCUIT BREAKER

quires much less clerical work, gives the workman more responsibility and still gives good results, and will now be outlined.

Each maintenance electrician is given certain definite equipment for which he is held responsible. No detailed report of each item inspected is required, but at the end of each day he is to make out a general report of equipment inspected and any important work done, such as changing oil in a circuit breaker, changing bearings or brushes on a motor or cleaning and overhauling a generator. This report is made in a ruled journal, a sample being as follows: "Inspected, and oiled where needed: All motors in Coal Plant No. —. Motors driving conveyors No. 36, 37, 38, 39, 40 and 41. Made repairs on interlock on No. 37 conveyor. Put new contacts on controller on drag line hoist at gravel washer. Took this motor apart and brought end bell to machine shop for new bearings—also brought rotor to electric shop for new wedges."

All these major items of repair are transferred to a permanent record, so that the past record of each machine is always available, as in Fig. 1. Weekly and annual reports are made in letter form to the superintendent.

To make sure that this man will be "on the job" and take an interest, the following incentive plan is used. The workman is given the regular wage, plus a bonus of 25 per cent if all equipment in his charge has operated without a delay during the month. If a delay occurs on any machine due to improper maintenance, a deduction is made from the bonus. A regular schedule is made out showing the amount of deduction to be made for each sixty minutes of delay for each class machine.

With this method, it is up to the maintenance electrician to work out his own program of inspection. He will soon learn what motors will need attention once a week or once a day, as the case may be. Of course, it is possible under this system for a man to have equipment in rather a sloppy state of repair, yet keep the wheels turning, by keeping his eye on the items most likely to give trouble. To avoid this condition the foreman should go over the route with each maintenance man at regular intervals to check up on general appearance of the equipment.

We have been using the latter method in several departments of our plant for several years with excellent results. Much depends, however, upon the type of man doing the work. We have been fortunate in having men who take pride in trying to keep the equipment entrusted to their care in the best of condition and in trying to see how long they can go without a delay. Many times the inspector will find equipment in need of repair for which he does not have time. With a report made out each night, the foreman can assign this work to some other electrician.

In many cases, in addition to keeping a record of repairs in the shop, a tag is attached to the equipment itself, Fig. 2. This applies particularly to oil circuit breakers, transformers, and oil-immersed starters. This card gives the date, description of repairs and names of men doing the work.

Any superintendent or manager having electrical equipment in his plant will find that periodic careful inspection and maintenance of electrical equipment will pay good dividends in fewer delays of production due to breakdowns and also in decreased repair costs.

Motor Mounts By Flanged Attachment

COMPARISON IS between direct-drive motors mounted by means of a foot or base at one side of the frame or on the bottom and those mounted by means of a flange on one of the end rings, usually having incorporated one shaft bearing.

As given by Herbert Chase in a discussion before the A.S.M.E., the flange mounting appears to be more a part of the design of the machine, is often more rigid and compact, saves weight and expense in the frame of the driven machine, is more easily attached and alined and generally gives better protection to the motor from oil, dirt and metal chips.

Against this, so far as the user is concerned, is the fact that mounting flanges are not standardized so that replacements, in case of trouble, are not easily made

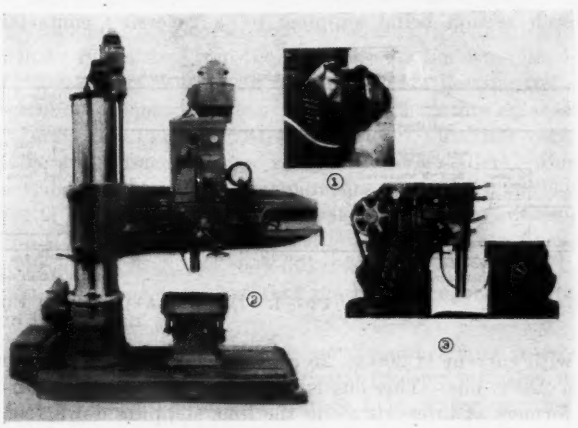


FIG. 1. MOTOR FLANGED TO SHAPER FRAME, FIG. 2. FLANGED MOTOR INSIDE OF FRAME, FIG. 3. THREE MOTORS FLANGE MOUNTED GIVE COMPACT DRIVE AND FLEXIBLE CONTROL

from stock of either the plant or the motor manufacturer. This is a matter of development, however, for base-mounted motors are not entirely standardized and it is really easier to effect interchangeability, especially as between a.c. and d.c. types, with flange mounting than with base mounting.

Because they are considered special, flange-mounted motors are, at present, somewhat more costly than base-mounted but this difference should disappear as flange-mounting becomes common.

By placing the motor on one side, on top or even inside the frame of a machine, compactness, simplicity of drive, reduction in floor space, better appearance and lower cost for motor and mounting are secured. The machine must, of course, be designed with provision for attaching the motor flange but this is usually simpler than providing a bracket for base mounting. Belt or chain drive can be readily arranged so that the same ranges of size and speed are available for either method of mounting. All that is needed to bring about standardization of flange mounting is sufficient appreciation of its advantages and demand on the part of users to create a dependable market.

In the illustrations, Fig. 1 shows a motor mounted on the frame of a shaper, Fig. 2 is a chain drive with motor inside the drill frame and rear view showing the

ventilating bell, Fig. 3 is a drill press with two motors mounted vertically and one horizontally. All are flange mounted and indicate the simplicity of adapting flange mounting to any kind of machine.

Manless A. C. Electric Cars*

REMOTE CONTROL OF CEMENT HAULAGE STARTS, REVERSES AND STOPS CARS. BY R. F. EMERSON**

CONTROL of four cars over a mile of track at the limestone quarry of the Trinity Portland Cement Co., Dallas, Texas, is accomplished with 3-phase alternating current by reversing switches on boards at the two ends of the line, without train crews. Cars weighing 42,000 lb. each, loaded with 22,000 lb. of limestone are operated at 13 mi. per hr. on standard gage track, over a 3 per cent grade loaded and 6 per cent grade empty.

Track is divided into 20 sections as shown in Fig. 1, each section being supplied by a reversing contactor

FIG. 2. EQUIPMENT AT QUARRY, CASES, SHOVEL AT FAR END, TRANSFORMER AND CONTROL CABINET

high resistance rotors are used to reduce starting current. By closing a contactor before a car reaches its section and opening contactors when their sections are empty, the contactors can be operated for the most part at zero current, thus avoiding tip burning. Contactors

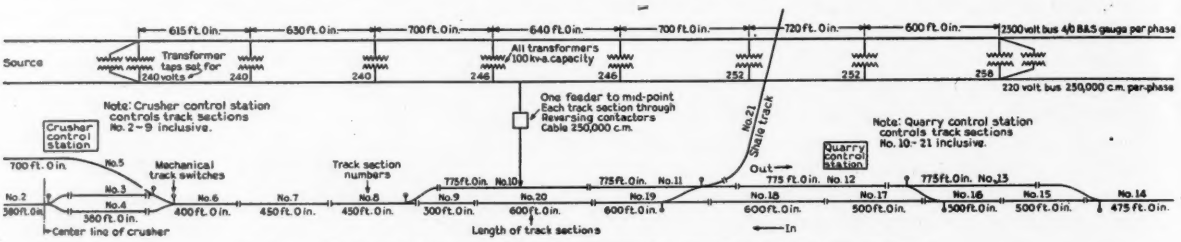

615 ft. 0 in.
630 ft. 0 in.
700 ft. 0 in.
640 ft. 0 in.
700 ft. 0 in.
720 ft. 0 in.
600 ft. 0 in.
2300 volt bus 4/0 B&S gauge per phase
Source
Transformer taps set for 240 volts
All transformers 100 kv-a. capacity
220 volt bus 250,000 c.m. per phase
One feeder to mid-point
Each track section through
Reversing contactors
Cable 250,000 c.m.
Note: Crusher control station controls track sections No. 2-9 inclusive.
Crusher control station
Note: Quarry control station controls track sections No. 10-21 inclusive.
Quarry control station
Shale track
Out
In
Mechanical track switches
Track section numbers
700 ft. 0 in.
380 ft. 0 in.
400 ft. 0 in.
450 ft. 0 in.
450 ft. 0 in.
300 ft. 0 in.
600 ft. 0 in.
775 ft. 0 in.
600 ft. 0 in.
775 ft. 0 in.
600 ft. 0 in.
775 ft. 0 in.
500 ft. 0 in.
775 ft. 0 in.
1500 ft. 0 in.
500 ft. 0 in.
475 ft. 0 in.
Center line of crusher
Length of track sections

FIG. 1. TRACK LAYOUT AND ELECTRICAL CONNECTIONS OF SYSTEM

with current at 200 v., 25 cycles per second, taken from a 220-v. bus. This bus is fed from ten 100-kv-a. transformers at intervals along the line, stepping down from a 2200-v. power line which feeds the electric shovel at the quarry.

Figure 2 shows the quarry face, cars, electric shovel, and some transformers and covered contactor cabinets.

From each contactor, control wires carrying about 1 amp. run to small reversing switches on the operators' desks, Fig. 3, all movement being controlled from two desks except for the three sections near the shovel which the shovel operator controls to hold incoming empties and send out loaded cars. Each reversing switch operates its contactor to start a car on the section which the contactor supplies, in either direction. When the switch is opened, the contactor opens, its track section is de-energized and any car on it is stopped by spring-operated brakes. These brakes are held in "off" position by a solenoid so long as the track section has current. Red and green lights show which way a car is to go on any track section.

Two squirrel cage motors are used on each car, driving through a double gear reduction to the car axle. Each brake-solenoid operating coil is connected across two motor terminals. As the current is 3-phase, two conductor rails are used with collector shoes for two motor terminals; the third terminal is grounded to the car frame, the track rails forming the third conductor of the system.

Motors have no slip rings or external resistances but at the terminals, which are closed to start cars, are the ones which do most of the work.

More cars can be added with no change in track or control system; additional track by extension of power lines and one control switch for each track section.

On down grades, motors operate regeneratively, thus braking the cars and feeding current back to the system so that runaway is practically impossible. Tests have shown average power consumption of 0.544 kw-hr. per ton mile.

The system requires an extra conductor rail and collector shoe as compared with direct current, also, unless

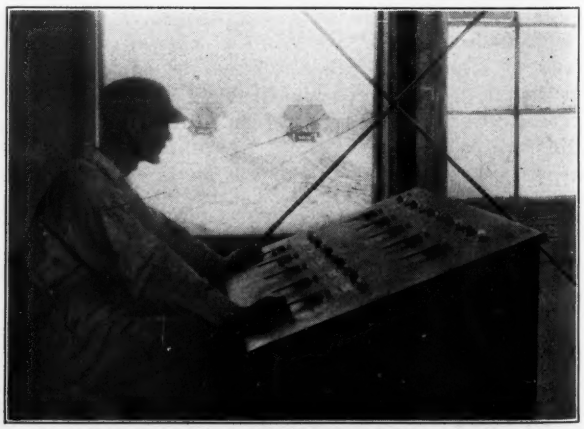


FIG. 3. CONTROL DESK IN CRUSHER HOUSE, WITH REVERSING SWITCH AND 2 INDICATING LIGHTS FOR EACH TRACK SECTION

**Industrial Eng'g Dept., General Electric Co.
*From a paper before Materials Handling Section of A.S.M.E. at Cleveland, Ohio.

large feeders are provided, voltage drop may be excessive when starting a car, since a squirrel cage motor may draw starting current eight times its running current. As starting torque drops in proportion to the square of the voltage, all four rails are bonded by accepted methods to reduce drop. Motors start on full voltage, hence must have a torque sufficiently powerful to drive a loaded car up the steepest grade yet not enough to spin the wheels of an empty car. As the motor is constant speed, there is no car speed control but inertia is sufficient so that cars can be spotted at shovel and crusher by jogging with the control switch.

Operation has been too brief to give definite data as to maintenance cost but simplicity and ruggedness of motors and control, also low power consumption would seem to offset such disadvantages as may be inherent in the a.c. system.

Belt Conveyor Life Increase

By W. E. Philips*

ON THE ASSUMPTION that, when the conveyor was originally installed, the idlers were lined up square with the belt, an experienced engineer's advice was taken when determining on the belt design for the material to be handled and that the belt was lined up correctly with the idlers, five simple things will materially increase the life of a conveyor belt installation.

1. Sufficient greasing with the proper kind of grease, although infrequently needed.

2. Keep the space under the belt clean. Do not overload so that material overflows but, if that happens, clean the decking above the idlers to prevent clogging them.

3. Use a belt designed for the service expected. Have material reach the belt in the same direction the belt is moving and with as little impact as possible. Use feeders when necessary as they create a steady flow of material without shock to the conveyor. Reduce belt speed according to tonnage requirements, keeping belt loaded to capacity but never overloaded.

4. Reasons for uneven or premature wear on belts and idlers are: Belts scraping against framework, skirtboards, or wedged material; dragging idlers, caused by insufficient lubrication; clogged rolls. All these cause undue wear on both the belt and idler and put an extra load on the driving mechanism.

5. Train the belt while empty, then, if it runs out of line when loaded, that is because of unequal loading. Fix the loading chute or install a feeder. Adjustment cannot be made by the takeups on one side or the other. See that the belt contacts the center roll of the idler because this steers the belt. Foundations for the idler should be firm and secure. No side or guide idlers should be used when training the belt. Increased belt tension will only injure the belt without obtaining the desired results.

*Engineer, Link-Belt Co., Chicago, Ill.

Oil viscosity decreases as temperature increases. At running temperature, viscosity must be sufficient to maintain the oil film between bearing surfaces, even though some power be wasted when starting up.

Anti-Friction Bearing Lubrication

SINCE bearing of a ball or roller of an antifriction bearing is of small area, the race metal is somewhat deformed into a minute ridge which travels ahead of the ball or roller. This gives a sliding action between the ridge and the rolling member so that lubricant is necessary to prevent destructive action. This lubricant must have high film strength, and adhesiveness to avoid forcing it out from between the surfaces under the high unit pressures which exist. Also high adhesiveness will lessen the tendency of lubricant to be thrown from the bearings.

To attain the desired qualities there is tendency to combine a base oil which prevents metal to metal contact with an oil having high lubricating value. Under high pressure, the base oil keeps the metals from touching and the lubricating constituent is squeezed out to do its part. As pressure becomes less, the lubricator will be reabsorbed into the base oil. As the same lubricant generally remains in an anti-friction bearing for a considerable period, it must be free from acids or acid-forming fats to avoid rust or corrosion. This bars vegetable and animal greases, soap and similar fillers. For bearings subject to low temperatures, especially if they are to be idle for considerable periods as for an automobile standing in a cold garage, heavy greases are likely to become stiff so that they interfere with bearing operation or become rutted so that the bearing operates with no lubrication.

Lubricant must reach the bearing either from a surrounding reservoir or by continual feeding sufficient to supply lubrication and to exclude dust, water or other foreign matter. Also some sort of seal should be used to prevent escape of lubricant and entrance of foreign matter.

Location of the bearing, temperature and cleanness of the surrounding air, also whether rotation is reversed, determine largely the kind of seal needed.

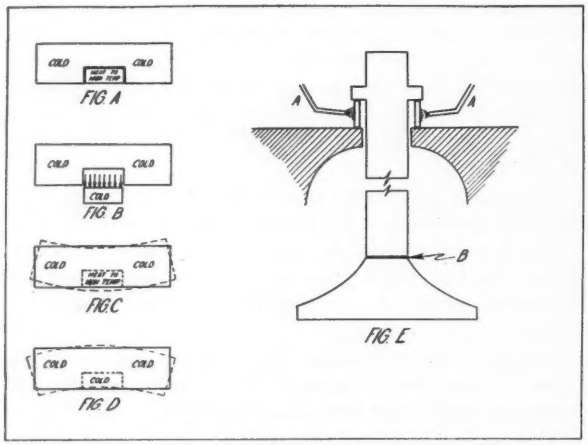
The seal may be a metal gland, fitting close to the shaft but not touching it, possibly with annular grooves in the gland to hold an oil film touching the shaft. For one-way rotation, a spiral groove may be used, tending to lead lubricant back into the bearing. Some springy material such as a felt or cork washer may be used as a seal, held by a groove in the bearing casing or a flange at the end of the bearing. For such use the felt should be long fiber to be durable and either felt or cork should have only sufficient squeeze to hold it firm and give a light bearing on the shaft. Too tight a fit will cause overheating and possibly grooving of the shaft. Shaft surface speed should be not over 2000 ft. a min. If over 1000 ft. a min. hard felt should be used.

For any bearing, especially for high speeds and pressures or severe service, lubricant should be removed, the bearing cleaned of all foreign matter and metal dust and new lubricant supplied, at reasonable intervals. Even a little dust may cause poor performance in tightly fitted bearings with highly polished surfaces, hence it is better to clean and replenish a bit too often than to leave bearings alone too long.—From Black & White.

B. T. U.'s—a Tool

IN THE FOLLOWING sketch is shown a method successfully used in teaching expansion, contraction and the reaction when a metal mass is being subjected to local heats.

In Fig. A is represented a heavy cold bar of steel that has had a recess milled across one of its surfaces



DIAGRAMS TO ILLUSTRATE PERMANENT DISTORTION DUE TO UNEVEN APPLICATION OF HEAT

and then a piece of steel machined and fitted perfectly into the recess. Assume the inserted block to be subjected to a high temperature, the rest of the bar remaining comparatively cold. Due to the inserted block's expansion, the bar will bend to the shape somewhat shown by the dotted line of Fig. C and at the same time the cold bar with its vise-like resistance will upset the inserted block so that, upon cooling the surrounding mass will return approximately to its original position and of course the inserted block will freely fall from its position, due to having been shortened, from upsetting, when hot. Now, assume that the block shown in the bar Fig. C has not been inserted, but instead is part of the bar itself. This time when heated to a high temperature, the cold bar will be bent as before, shown by the dotted line in Fig. C and will be upset as before. When cooling, the entire bar will tend to resume its approximate original shape, as shown by the heavy line, Fig. D but in this case, the heated block, now being a part of the bar itself and having been upset, will continue to contract and bend the bar in the opposite direction, as shown by the dotted line, Fig. D.

Now, here might be a valuable suggestion: Should you want to straighten the bent bar, Fig. D, heat along the side opposite the block, that is the convex side, at first the bar will continue to arch farther in the direction it is now bent but keep intermittently applying your heat and you will eventually see the bar begin to move back and tend to straighten itself to its original position. Remember that all of this takes place in a piece of metal any time any part of its surface is subjected to a high temperature.

In Fig. E is shown a method of lifting an extremely heavy shaft in a vertical position. When the separation at "B" is of a small dimension, two heavy pieces of metal can be firmly wedged under the shafts upper flange and heated with torches as shown at A. The method described above has been valuable to the writer in teaching welding in railroad shops, navy, yards, construction and power plant work.

Mishawaka, Ind. E. T. DAVIS.

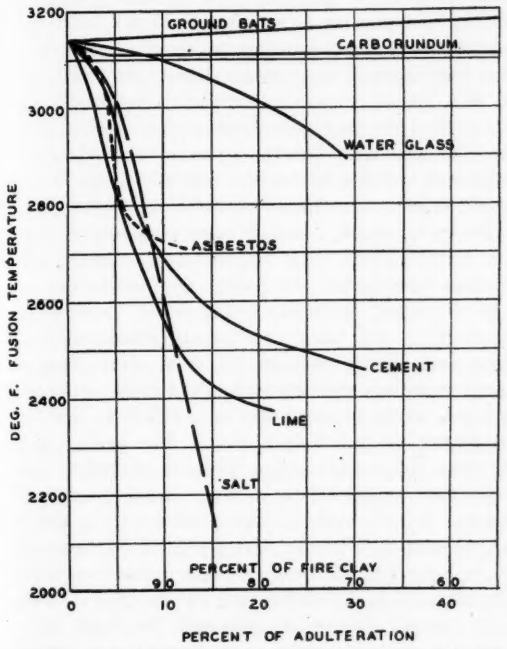
Effect of Various Materials on Fire Clay Mixtures

MANY TIMES engineers or, perhaps we should say, masons who lay up firebrick, think that fire clay mortars or even plastic-fire clays, can be improved by the addition of various materials such as water glass, lime cement and asbestos. The fact that the need is felt for the addition of some material to improve the working and setting properties of the clay, for instance to make it set cold or offset the natural shrinkage, is evidence that the fire clay alone does not meet the demands of all conditions. As a matter of fact the shrinkage is enough to cause trouble but refractory manufacturers think that the way to overcome this natural tendency is by the addition of similar well seasoned material such as finely ground first quality bats.

Practically all other materials cause a decided decrease in the fusion point of the mortar as much, for instance, as 700 deg. F. for a 15 per cent addition of salt. In fact, 5 per cent of lime, cement, salt or asbestos reduces the fusion point about 350 deg. F. The influence of carborundum and water glass is less, the former being, in fact, negligible, while the addition of ground oats actually increases the fusion temperature. The experiments shown on the attached curves were, I be-

lieve, made at the Mellon Institute some years ago and are of great value in showing what may be expected of certain materials upon which high-pressure, high-rating boiler practice has focused attention. If used at all these foreign ingredients should be used sparingly, the best things to use being, of course, alumina or silica which compose the major portion of the natural clay.

A typical plastic clay runs about 56 per cent silica, 28 per cent alumina, 11 per cent volatile, 3 ferric oxide and 2 per cent lime, magnesia and other alkalies. The fusion point of the original clay shown on the curves



FUSION-TEMPERATURE CHANGES OF FIRE CLAY CAUSED BY MIXTURE WITH VARIOUS SUBSTANCES

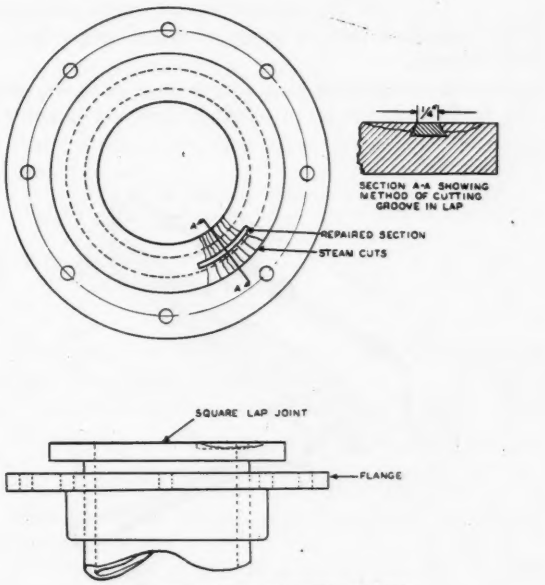
was Cone 30 or about 3000 deg. F. Regardless of the cement, the joint should be laid up as thin as possible for high temperature work for it is obvious that the cement cannot be expected to have the same resistance as the brick itself which should be selected for the specific conditions.

Brooklyn, N. Y. P. F. ROGERS.

Repairing Square Lap Joints

IT IS WELL KNOWN that a leaky gasket on a high pressure steam flanged joint will allow the escaping steam to cut the face of the flange severely. The cutting is more severe if the steam is superheated. The cutting action is rapid and if allowed to continue for any length of time, the face of the flange will be injured beyond repair. The author was present when a leak of this kind was repaired, after being allowed to go for a week. The leak, fortunately, was on a square lap joint under a flanged valve. The valve was removed and both flanges of the valve inspected and found not to be injured. The square lap joint on the neck of the 4-in. riser, however, was badly cut around the face of the valve for a distance of 1⅛ in. The cut was about 1/6 in. deep in the worst place.

A dovetail shaped groove, running concentric with the flange, was chiseled out. The groove was cut ¼ in. wide at the top and a little wider at the bottom with the depth of the groove 1/6 in., i.e., as deep as the steam had cut. The groove must be chipped well beyond the range of the steam cuts. A ¼-in. annealed monel metal rod of the proper length was well peaned into the dovetail groove; then filed flush with the smooth surface of the square lap joint. If no monel metal is at hand, an annealed copper rod will serve. To prevent bending the lip of the square lap, the loose flange was securely wedged in place. When the flanges were bolted up a plain corrugated steel gasket, covered with a popular brand of pipe compound soluble in water, was used. The leak mentioned was repaired two years ago and is still tight. This kind of a leak was also repaired successfully by arc welding, using reverse polarity. A bead



DETAILS OF REPAIRED JOINT

of coated monel metal was laid on and then peaned and filed flush with the uncut face of the square lap joint.

Springfield, Mass. BRADFORD JAMIESON.

Relief Valve Location Is Important Safety Factor

ON PAGE 316 March 1 of Power Plant Engineering, A. J. Dixon shows a relief valve placed on top of a hot-water tank. Experience has proven that a relief valve so placed is not to be depended upon as a safety device after it has been in use a comparatively short time.

Years ago, plumbers discontinued installing such relief valves on domestic hot-water boilers.

When any untreated makeup water enters such a tank a thin skin of scale will in a short time form around the seat of the relief valve and hold it shut against a great pressure.

If the valve were taken apart every day and the sediment around the seat removed, it would be all right; otherwise it is not a reliable safety device.

If the danger of excessive pressure is all in the by-pass, why not place the relief valve in it? As only con-

densate goes through the bypass there will be small chance of scale forming.

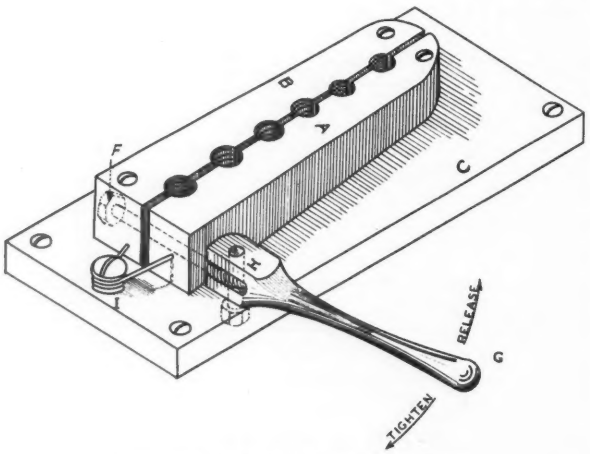
Unless the vacuum check valve is operated quite often, dirt will collect behind the seat and hold the valve closed. An inexpensive connection can be installed easily so that water can be blown through the vacuum valve to keep it clear of dirt. Of course if the operation of the pump causes the vacuum valve to open frequently nothing else is necessary. Many cases have been recorded where check valves, safety valves, and the ordinary design of relief valves have proven unreliable when used on hot water tanks using raw water as supply or makeup.

Toronto, Canada JAMES E. NOBLE.

Screw Vise

FOR THE small amount of effort that it requires to make it, there are few better ways to hold screws and studs than in a regular screw vise that grips them by their threads.

In the illustration is a simple one to make, which will firmly grip the screw or stud while one is sawing a



DETAILS OF SCREW OR STUD VISE

slot in it, drilling a cotter hole or rechasing the threads with a die. It is made by first drilling and tapping a series of holes suitable to the sizes of studs or screws most used and then sawing down through the center of these to make two sections. Next the two pieces A and B are mounted. One marked B is fastened permanently to the base C by several large machine screws and the one marked A is pivoted at E by another large screw drilled and tapped into the base plate. At F an eye bolt passes through the two parts and a clamping lever G with a cam face H produces the gripping pressure. A coiled spring I with an end in each part, is held by a screw and opens the jaws when the lever is released. A longitudinal slot is cut in the plate under the fixture to permit the longer screws to pass through. The whole fixture can be secured to the bench or held in the vise as desired.

Concord, N. H. CHAS. H. WILLEY.

WHEN WORK is done at the rate of 550 ft. per sec. or (550 × 60 =) 33,000 ft-lb. per min., it is arbitrarily defined as a horsepower, the most commonly used unit of power.

Repairing of Leaky Scroll Case

IN A WATER TURBINE PLANT a riveted steel-plate, spiral casing was giving trouble by leaking through the concrete masonry in which the casing was buried. The leakage came out on the downstream wall and followed a construction or pouring joint for part of the way. The scroll case was proved guilty for coloring matter introduced into the pipeline appeared at the downstream point of discharge.

The water turbine had been in service a number of years and had been subjected many times to pressure rises of 40 per cent above normal operating head; these shocks in time loosened the joints. It is hard to understand why these riveted seams loosened inasmuch as the casing was buried in concrete; the deformation, however, was probably circumferential. Not much springing is needed to produce leakage under a head of 225 ft.

In the last year before the case was repaired, the leakage was rapidly increasing and something had to be done about it, as the management feared building cracks in freezing weather. It had been proposed to line the entire scroll casing with cement-sand mixture but the point was raised that the lining might soon be coming out of the draft tube like cracked ice, because of the pressure rises, the idea was hastily abandoned. Then coating with metal, shot on the steel plate from a sort of spray gun, was considered but the final cost was high.

Then a welding contractor was called in and offered to guarantee the job he proposed. The price was much lower than the metal coating process, therefore welding was decided upon. Every seam, where such riveted seams are usually calked, was welded with a gas torch, using the standard round wire rods. A manhole located near the entrance of the steel-plate spiral was left open for ventilation and a cofferdam put in that tailrace bay so that the air coming up through the draft tube and the runner, with the gates open, furnished a ventilating draft.

This repair has to date stopped the leakage. The management at first considered welding around the rivets which might be considered most theoretically to be most highly stressed but this was abandoned on account of the cost, also because of the reduction in passage area that this might cause.

Hanover, Pa. JOHN S. CARPENTER.

Magnesia Block Dust Prevention

HANDLING of magnesia blocks and shapes is a dirty job, as the blocks give off a cloud of magnesia dust every time they are moved, or handled.

When I was given the job of covering a large tank with magnesia blocks, yet not mess up a newly completed department, a problem arose.

I found a good way to stop this dust was to paint the blocks with a coating of a solution, one-half water and one-half water glass, allowing the coating to dry thoroughly.

No dust arose from the blocks and shapes unless they were cut or broken.

Springfield, Mass. BRADFORD JAMIESON.

A MACHINE installed in a few days must be operated for years. It pays to spend a little time selecting it so that it suits the job.

Boiler Construction Details

WHAT PROVISIONS are made for expansion and contraction of boiler tubes? 2. What is the advantage of two or more courses of tubes in return tube boilers? 3. How many rivets and what size is required to fasten a 1-in. brace in a boiler? W. R.

A. No provision for expansion of tubes is necessary with horizontal return tubular boilers as the shell expands with tubes. With bent tube boilers, the springing of the tubes is sufficient to care for the expansion. Expansion of straight tubes is cared for by the connection to the drums.

2. With two or more courses, or rows of tubes, in a return tubular boiler you have more heating surface in the same cubical space.

3. Assuming that the strength of the brace has already been computed and taken into account, then rule 8 in par. P-223 of the A.S.M.E. boiler code would cover your question. This rule states: Make the combined cross-sectional area of the rivets at each end of the brace at least 1¼ times the required cross-sectional area of the brace.

To find the cross sectional area of a 1-in. brace, we follow the usual method of finding the area of a circle which is $0.7854\ d^2$ or 0.7854×1^2 or 0.8 nearly $1\frac{1}{4} \times 0.8 = 1.0$ sq. in. Therefore, if you have two rivets at each end of the brace the cross sectional area of each would be ½ sq. in., or about a ⅞-in. rivet. There is no set rule as to the number of rivets that must necessarily be used to fasten a brace.

Computing Equivalent Evaporation

IF A BOILER generates 1000 lb. of steam per hr. of 98 per cent quality gage pressure = 100 lb. temperature of feedwater 100 deg., what is the equivalent evaporation from and at 212 deg.? W. R.

A. In computing the equivalent evaporation, we use the following equation:

$$F = \frac{h - q_2}{970.4}$$

in which h = heat content of 1 lb. of steam at observed pressure and temperature or quality, B.t.u. per lb. above 32 deg. F.

q_2 = heat content of 1 lb. of feedwater at observed temperature, B.t.u. per lb. For most purposes $q_2 = t_2 - 32$ in. in which t_2 = temperature of the feedwater in deg. F.

F = the factor of evaporation, which is the ratio of the heat absorbed in evaporating by 1 lb. of feedwater under actual conditions to what it would absorb if the pressure were 14.7 lb. abs. and the feedwater temperature 212 deg. F.

970.4 = latent heat of 1 lb. of steam at atmospheric pressure.

The values of h for saturated and superheated steam may be found in steam tables. For wet steam, h may be calculated from the relationship:

$$h = xr + q$$

in which

x = quality of the steam.
r = latent heat at observed pressure B.t.u. per lb.
q = heat of the liquid at observed pressure B.t.u. per lb.

Substituting the values given in your letter we get the equation

$$F = \frac{(0.98 \times 880 + 309.08) - (100 - 32)}{970.4}$$

which gives us

$$\frac{1103.44}{970.4} = 1.1$$

The actual evaporation at 100 lb. pressure is 1000 lb. per hr. Then multiplying 1.1 by 1000, we get 1100 lb. per hr., which is the equivalent of evaporation from and at 212 deg. F.

Oil in Boiler Causes Bags

EXPLAIN WHAT damage may be done to a boiler by getting oil into it? R. B.

A. When oil, which is a poor conductor of heat, lodges on the fire sheets or tubes, overheating of the sheets or tubes may result. The overheating may then cause the plates or tubes to bag or bulge, thus weakening the material and inviting rupture.

When an unsuitable grade of oil is used for engine cylinder lubrication, its complete separation from the condensate or exhaust steam may be extremely difficult. Only liquid oil can be removed by the oil separator of an open feedwater heater and because some of the constituents of an unsuitable oil may vaporize at steam temperature they may be carried into the feedwater and through to the boiler. Filtering, skimming and even chemicals are sometimes used to remove the last traces of oil.

Bearing Adjustment

ON PAGE 279 of the February 15 issue of Power Plant Engineering, the answer to the question on bearing adjustment is misleading. It says to put soft lead wire between the shim surfaces and compress them in the process of drawing down the bearing bolts.

The place for the soft lead wire is between the journal and cap then pull down bearing bolts on the shims. The lead would give you the clearance between the journal and cap.

Waverly, Mass. R. B. ROWE.

Editorial Comment

Rating Advertised Products

To be advertised continuously and be successful, a product must have merit and must make good. Products with plus values, beyond those needed barely to get by are the ones worth while using and which are advantageously advertised. Any soap helps in washing but a soap which makes washing much easier and quicker, is harmless to fine fabrics and the hands or does the work with a less amount will by advertising be established in a preferred position. It will rightly have a rating higher than common soap and be considered by the buyer as worth a higher price. That a product has been advertised over a considerable period and has made good is insurance of reliability and fair dealing of the maker. To establish and maintain reputation, the manufacturer must work up to a standard of performance and reliability, not down to a price-cutting basis. This is another point justifying high rating of such products.

The claim sometimes advanced that "we give customers a reduction in price rather than spend money in advertising" is usually made for a product not worthy of advertising, by a manufacturer who seeks only a limited market for a small output and who has generally a high production cost per unit produced. His whole effort is toward low price, which he advertises by word of mouth, rather than toward improved product.

Experience and the history of advertised goods show that sales cost is decreased and volume of output so increased by proper advertising that cost of production and distribution per unit of product is decreased and the buyer gets more value per dollar of price than without advertising.

Taking these points into account, the buyer who is in the market for equipment may well consider what rating he should give to advertised products as compared to those built for price competition. It would seem reasonable to allow a differential in favor of the former because of their standards and records. One suggestion has been made that a 10 per cent preference be given in price comparisons or that specifications be so rigidly drawn that only reputable products can meet them. The differential may probably well vary according to the equipment but some method by which those products which have established their right to it can be given preferential consideration and rating, will contribute to advancement in engineering practice and to satisfaction with the performance of equipment after purchase.

Another Harness for Nature

Progress in the generation of power for the use of mankind from the very beginning has been the result of methods devised for utilizing both the kinetic and potential energy found in nature. Wind and falling water were among the first forces to be brought to the service of man and for ages the conquest of nature's kinetic energy rested there but the production of artificial heat from fuels tapped a reservoir of potential energy that is still the principal source of power for industrial and domestic use.

Within the present generation, attempts to secure power from ocean waves and tides have met with partial success. The heat of the sun has been experimented with to generate steam for power use. Geysers in Italy and California are giving up their heat for the generation of steam at low pressure to be used in turbines for power purposes. Within the past year an experiment was made to generate power by means of ocean water utilizing the heat drop due to the difference in temperature of the water at the surface and at great depths.

Now comes the turbine run by the pressure of natural gas as it comes from wells. The principles involved are not new but converting this pent up energy into useful power is a comparatively recent scheme to harness nature. One plant has employed this scheme with such success that additional units are being installed.

Inasmuch as this source of energy is limited to gas field locations which are not great in area and the pressure continuously dwindles, it can be considered in only a few locations but the installation which is described in this issue is a striking example of initiative on the part of engineers in making use of available resources that have heretofore gone to waste.

Off Duty

In this marvelous age when everybody visits their dentist twice a day and brushes their shoes twice a year, when every family has two cars and a Telechron, when radios fill the homes throughout the land with the overtones of culture and the howlings of ninth-rate vocalists, and with television (God help us) just around the corner, it is difficult sometimes to understand how the human race ever survived the dangers, now removed by radio announcers, which beset it on every side. With the dreaded staphylococcus aurens lurking in ambush behind every bicuspid, with the horrors of B.O. and halitosis ever staring us in the face and with the cruel tentacles of the insidious power trust reaching for our vitals even as we write, we marvel that the race ever survived to this day. And yet we have not even mentioned the dangers of eating of meat.

The horrible effects of the latter are almost too terrible to contemplate but in the interest of science and humanity, it is necessary for us to dwell upon this distasteful subject, for who knows but that in a moment of abstraction, the purest of us may inadvertently swallow a frankfurter or with malice aforethought have designs upon a porterhouse steak. Though we shudder at the thought of anything so awful befalling our loved ones it is not out of the range of possibility; in fact, we have tendencies that way ourselves.

The trouble, of course, is that we are not sufficiently developed—we haven't quite reached the stage of cows

for example. Cows are sensible. They don't crave porterhouse steaks.

Admirable as this quality may be, our bovine friends deserve little praise since it is their nature to be vegetarians. Owing to the operation of certain natural laws cows, in common with elephants and giraffes long ago adopted themselves to an exclusively vegetable diet. As a consequence they are equipped with a digestive system which is peculiarly fitted to deal with this rather uneconomical form of nutriment. Various devices, such as four-pouched stomachs, and cud chewing helps them prepare and digest their food and special bacteria which flourish in their intestines convert cellulose into forms which can be assimulated. Their digestive juices are essentially designed for reducing carbohydrates rather than animal tissue.

We are quite different in this respect. Our digestive system more nearly resembles that of the dog, the cat, the eagle and the flea—the true wheat eaters, and it is evident that if we are better adapted to one kind of life than another, we are immensely more capable of leading a carnivorous than an herbivorous existence. Our stomachs are simple affairs and our digestive tract short. Digestive juices in the form of pepsin and trypsin, ideally capable of reducing animal flesh to chemical compounds utilizable by the body are poured into the system in great abundance. We have no means, however, of assimilating cellulose.

Thus, it would seem that meat is a natural food for us, and if, despite the solemn warnings of the exponents of dietetics, we still insist on storing away quantities of porterhouse or roast veal, perhaps we should not be condemned too severely. Apparently we were born with these tendencies.

To the vegetarians, of course, such mere facts as physiological fitness and natural adaptation bear little weight. They are disposed of with a wave of the hand or a pooh pooh, or a shrug of the shoulder, and justly so. For why should facts be permitted to interfere with anybody's preconceived ideas? Of what value is a pet theory if it can be upset by every little fact that comes along?

Indeed, Alexander Haig, M.D., who first popularized the dangers of meat eating in modern times, never permitted facts to interfere with his ideas. In a book, "Uric Acid as a Factor in the Causation of Disease," published in 1892, he propounded his theory that high blood pressure, rheumatism and Bright's disease were caused by an excess of uric acid in the blood and that uric acid in the blood was caused by eating meat. Hence, if one stopped eating meat, the high blood pressure, the rheumatism and the Bright's disease would disappear. This was so simple even a congressman could understand it.

As a matter of fact this theory had only two faults. First, it has never been proved that uric acid in the blood is caused by eating meat and second, there is no evidence to show that uric acid causes any diseased conditions.

Indeed, when this whole matter of meat eating is investigated critically, we find much more evidence to show that it is the lack of meat rather than the presence of it that is harmful. The so-called deficiency diseases it is true have been found to be due largely to the lack of certain substances called vitamines which are found in many vegetables and fruit as well as in meats, but there are certain well defined diseases such as Pellagra which arise when meat and animal products are withheld. Pernicious anemia also, it appears, is a meat deficiency disease as is seen from the remarkable cures effected in this disease by feeding patients liver.

Because of these facts and many others based on studies of races of people who eat meat exclusively, it is quite evident that the health warnings against meat eating are not only absurd but positively harmful. Vegetarians, of course, escape danger by eating animal products in the form of eggs, milk, cheese and gelatins and by means of these they are able to support their theories, but there are no conclusive experiments which show that human life can be supported efficiently on an exclusively vegetable diet.

It is not our intention here to imply that man is exclusively a carnivorous animal for that is not true. In addition to the digestive juices which reduce animal tissue in our stomachs we also have juices which are efficient in reducing vegetable carbohydrates. In short, man is to be classed with the robin, the amœba and the goldfish as an omnivore but he is much more of a carnivore than an herbivore. Even his teeth are essentially carnivorous. He is more suited to a meat than a vegetable diet.

Now this is exactly what we set out to prove when we started to write this article. As may be suspected, our predilections are all towards porterhouse steaks, fried chicken "ala Maryland" and roast lamb and we had no intentions of permitting anything to interfere with our ideas on this subject. For as we intimated before, what is the use of having a theory if you can't defend it? Each to his own opinions, however, and while those pure, rabbit-like souls who think that meat is dangerous are preparing their daily ration of spinach and carrots, we are getting ready to sink our decidedly more carnivorous teeth into a great juicy beefsteak.

RAINFALL is expressed as inches in depth and the rate in inches per hour or per day. For comparative purposes, stream flow may be expressed in the same way, meaning inches in depth over the entire watershed. One inch of rain is equal to 2,323,200 cu. ft. per sq. mi. For other purposes, stream flow is expressed in cubic feet or cubic feet per square mile of watershed, and rate of flow in cubic feet per second or cubic feet per second per square mile of watershed.

For the hydraulic power engineer, the question of stream flow divides itself into three parts: the minimum flow of the stream, the maximum or flood flow and the variations through months and years. The first is necessary to determine the power possibilities, particularly the necessity for storage or the possibility of a run of river plant. The second is necessary for the design of proper spillway capacity for adequate protection and the third is necessary for determining the storage necessary and the provision for standby or reserve capacity.

Dry weather flow is maintained largely by ground and surface storage. Surface storage increases losses due to evaporation but usually increases the minimum flow. Streams with narrow valleys and steep drainage slopes have high maximum runoff which may be two to four times that of streams with wide valleys and natural lakes, or flats bordering the stream which tend to distribute the runoff over a longer period of time.

Power Plant Engineering Developments and News

Taylor Stokers for Hudson Ave.

LARGEST Taylor stokers sold, the 15-retort, 69-tuyere stokers now being assembled at the shops of the American Engineering Co.; are for the Hudson Avenue Station of the Brooklyn Edison Co. They are approximately 27 ft. long and 26 ft. wide.

Radical departure from the ordinary means of actuating the secondary feed rams is one of the features. Each secondary ram or pusher rod has been brought out to the front of the stoker where the stroke can be individually adjusted.

One of the principal considerations in design was the necessity of providing for expansion and contraction of the fuel-carrying structure with changes in temperature. The lower end of the stoker rests free on rollers while the upper end carries into a hinge joint. If the stoker expands, it moves out upon the rollers and, of course, about the hinge joint. Transverse expansion across the furnace is taken care of within each retort so that there is actually no increase or decrease in the width of the stoker with a change in temperature, it is stated.

Crusher rolls and the drive of the Brooklyn Edison stokers will be powered by a Hele-Shaw transmission, consisting of hydraulic pump and motor, direct connected, and a hydraulic motor on the speed shaft of the power box. Rate of discharge from hydraulic pump to hydraulic motor can be varied within a range of 20 to 1 by moving the rotating member off center.

The hydraulic stoker motor is designed on the same principles as the pump except that since it has a constant displacement its rotation varies directly with the rate of flow from the pump. Any speed between zero and maximum of the pump will be available, providing a very flexible drive.

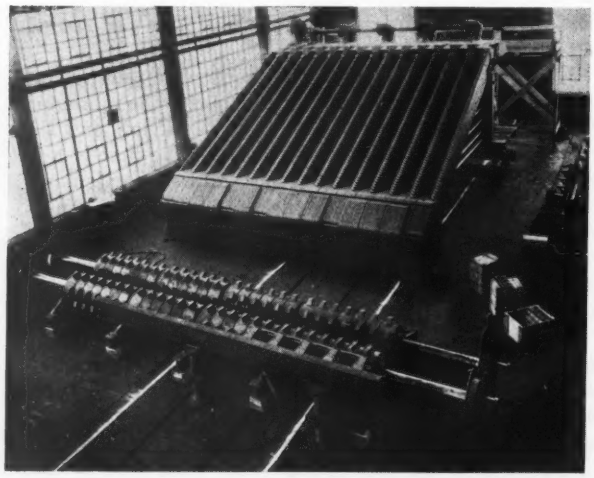


FIG. 1. GENERAL VIEW OF NEW HUDSON AVE. STOKERS

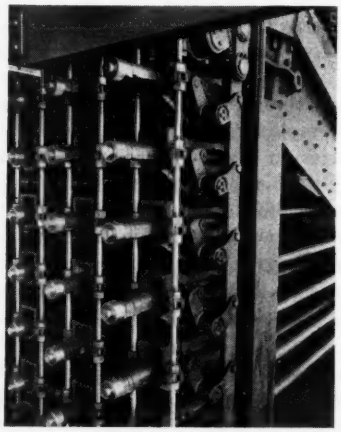


FIG. 2. PUSHER ROD ACTUATING MECHANISM AT STOKER FRONT

At maximum rating, the Brooklyn Edison stokers are designed to burn 28.3 t. of coal an hour, almost 2 t. per retort per hour.

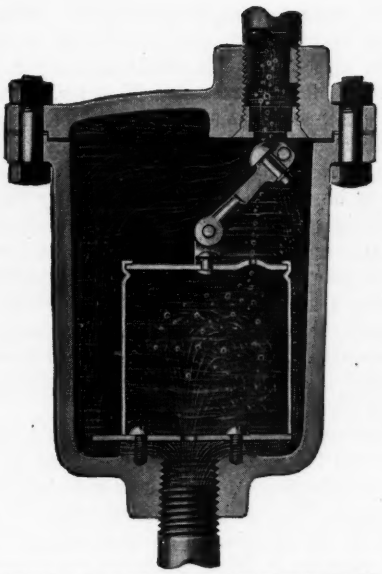
Silvertop Steam Trap

NEW STEAM TRAP to be known as the Silvertop Model A steam trap, an inverted bucket, self-venting trap, has recently been developed by the V. D. Anderson Co. of Cleveland, Ohio.

The name Silvertop was given to this trap because the top portion of the trap is finished in silver-colored paint and the body of the trap in copper color, the whole designed to make a distinctive-looking steam trap.

These Silvertop traps have pipe connections from ½-in. to 2-in. and are built to operate at pressures from vacuum to 300 lb. All valves and seats are made of nitralloy, to resist erosion. In addition to this, all the mechanism, including the levers and pins, is made of a heat-treated, rust-resisting alloy, to assure everlasting operation. The gasket is fitted into a recess, to insure it against any possibility of gasket blowouts.

Among the numerous features claimed for the Silvertop trap is its simplicity. The valve is mounted on a lever, to eliminate compound levers and valve stems which might retard the flow of discharge. Another feature is the Anderson deflector on which the inverted



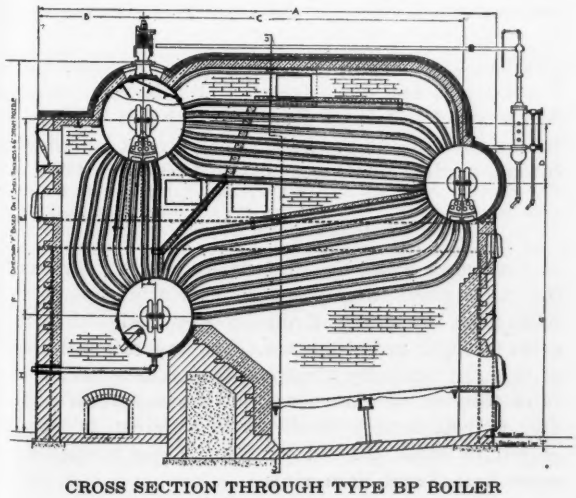
CROSS-SECTION OF SILVERTOP TRAP SHOWING AIR AND CONDENSATE DISCHARGE AND ACTION OF DEFLECTOR AT BOTTOM

bucket rests when the trap is discharging. In the center of the deflector is a small orifice to prevent an excess of inflowing condensate from impinging upon the bottom of the bucket, which would cause it to rise and partially close the valve. The excess condensate is deflected toward the trap body and passes up through the trap on the outside of the bucket. The deflector, in diverting the inflowing stream, is designed to wash the heavy sediment not in suspension from the bottom of the trap and carry it off with the discharging condensate. Silvertop traps are exceedingly light for their large capacity, it is stated, and can easily be supported by the connecting pipe lines.

Type BP Water-Tube Boiler for Low Head Room

TYPE BP WATER-TUBE BOILER, a low-head-room design, has recently been placed on the market in sizes ranging from 650 sq. ft. of steam surface to 5800 sq. ft. by the E. Keeler Co., of Williamsport, Pa. Details of the drum and tube construction are shown in the accompanying illustration. All tubes are bent to the same radii by a machine designed by Keeler engineers and built in the company's own plant. A permanent record of the length of each tube and tube bend is kept to facilitate replacement.

Each boiler or battery of boilers is supported by structural steel frame work, independent of brick work, so as to allow for expansion or contraction without undue strain either to the boiler or frame work. The settings are designed so that the tubes may be replaced without disturbing the boiler or connections. Arrangement of baffle walls and design of furnace will be made to meet particular requirements of operation, fuel available and furnace equipment installed. The type BP boiler is designed to have a height from boiler floor line to flange on steam outlet connection, ranging between 14 ft. 2½ in. for the smaller sizes to 16 ft. 8¼ in. for the larger sizes.

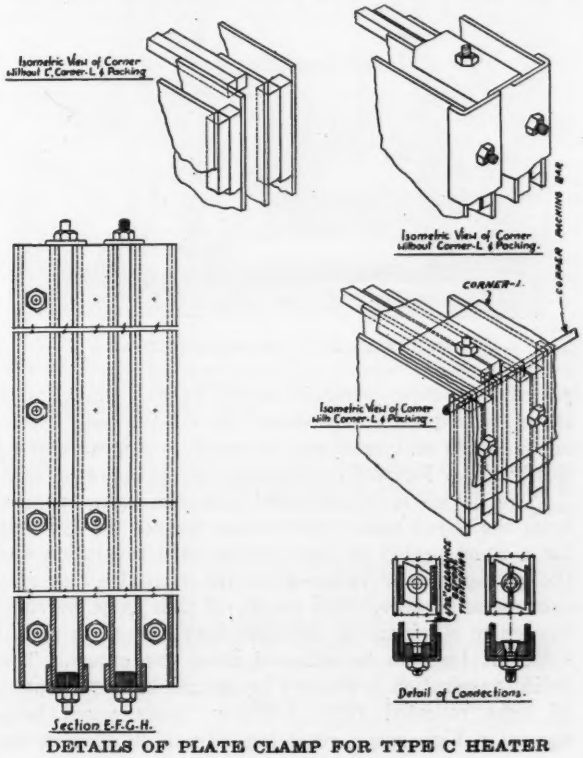


CROSS SECTION THROUGH TYPE BP BOILER

Improved Thermix Type C Air Heater

THERMIX TYPE C AIR HEATER in improved design has recently been placed on the market. It is shown in the accompanying illustration. According to its manufacturer, one of the features of the Thermix air heater design has always been to utilize plates direct from the mill and to eliminate welded joints in the gas and air elements. In recent developments it has been found desirable with high temperatures to eliminate as much as possible any kind of plate clamp or spacer from the direct path of the hot gas.

The new Thermix type C now being placed on the market by Prat-Daniel Corp. of New York City utilizes


Isometric View of Corner without C. Corner-L & Packing
Isometric View of Corner without Corner-L & Packing.
CORNER-L.
Isometric View of Corner with Corner-L & Packing.
Section E-F-G-H.
Detail of Connections.

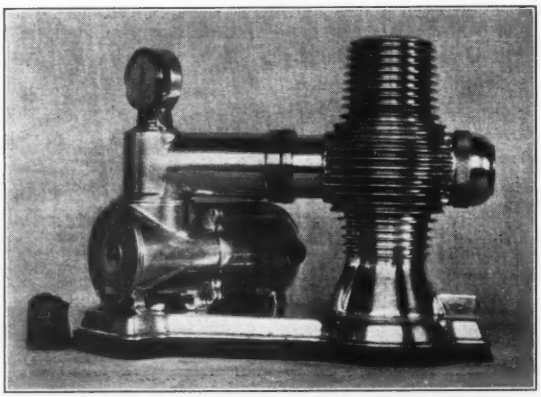
DETAILS OF PLATE CLAMP FOR TYPE C HEATER

a vise clamp for the edges of the plates, as shown. This is composed of a channel, of nickel chrome steel where necessary. Against the inside of the flanges of this channel rest the edges of the heater plates. The plates are forced tightly against the channel flanges by two parallel bars which in turn are forced apart by the shoulder of a special bolt. This bolt fits in counter-sunk openings between the bars and is tightened by a nut on the outside of the channel.

Resulting tightness of the joint and re-enforcing of the plate edge essential under high temperature have been extensively tested, according to the manufacturer. First study of the design of the joint often brings up the question of the possible greater expansion of the channel in the path of the hot gas than of the interior bars in the relatively colder air. Calculation shows, it is stated, that with high temperature differences, this expansion is about 0.003 in. which in turn is divided between four contact surfaces. Actual tests reported by the manufacturer with a temperature of the channel of 1200 deg. F. and a cold air jet played on the interior clamping bars show that sufficient tightness was maintained to hold a weight of 500 lb. per lineal foot on the plates.

Tackiscope for Observing Motion

TACKISCOPE has been developed to enable an observer to study the successive phases of varying motion through the projection of interrupted light flashes upon the object. When the instrument is so adjusted that these periodic flashes have a proper synchronous frequency, it is stated, the moving body apparently stands still or it can be made to appear moving slowly either forward or backward as the operator wills.



GENERAL VIEW OF TACKISCOPE

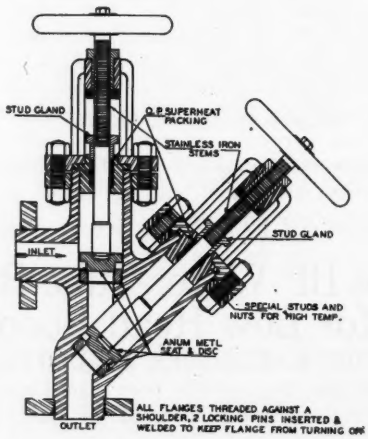
The device is so arranged that the light reflected from the object under observation reaches the eye only for a short period of time during each revolution and the persistence of vision gives the mental effect of a continuous picture. The length of time must be short enough to eliminate all blur but long enough to permit sufficient light to be reflected from the object. This delicate operation is effected by mechanical interruption of light reflected from a 200-w. incandescent lamp against a high speed revolving mirror or mirrors, the number of separate and distinct flashes being made to correspond exactly with the revolutions of the moving part. The velocity of this revolving mirror, which has a speed range from zero up to 33,000 r. p. m., permits of rapid synchronization and is controlled by a small friction drive disk at the back of the instrument.

The instrument is designed to be conveniently portable and to be plugged into any ordinary electric light socket, taking either direct or 25 or 60 cycle alternating service. It is only 14 by 11 in. over all and it weighs less than 12 lb. complete. The case or outer shell is of cast and tubular aluminum alloy and the working parts are of machined bronze and bakelite. The important elements, consisting of a 1/15-hp. Universal Motor, 200-w. incandescent lamp and base, mirrors, lenses and reflector, are of standard manufacture.

The instrument is designed to aid designers, factory engineers and the more technically trained research men in plant or laboratory but its uses are claimed to be as varied and manifold as the different types of machinery built. It is being placed on the market by Robert Dornner, Buffalo, N. Y.

Combination Blowoff Valve

STRONG COMBINATION STEEL BLOWOFF VALVE shown here has recently been placed on the market. It was especially designed for high-pressure service and to eliminate the necessity of installing two separate valves. The body is machined from a solid forging. Special Anum metal seats and discs are used and so arranged as to close with the pressure. The valve is a product of Strong, Carlisle & Hammond Co., Cleveland, Ohio.


STUD GLAND
O.P. SUPERHEAT PACKING
STAINLESS IRON STEMS
STUD GLAND
INLET
SPECIAL STUDS AND NUTS FOR HIGH TEMP.
ANUM METL SEAT & DISC
OUTLET
ALL FLANGES THREADED AGAINST A SHOULDER, 2 LOCKING PINS INSERTED & WELDED TO KEEP FLANGE FROM TURNING OFF

CONSTRUCTION DETAILS OF STRONG BLOWOFF VALVE

CRESCENT TOOL CO., Jamestown, N. Y., announces that after about three years of experimental work, it is placing on the market Crestoloy steel designed to have great strength and toughness. The first tool to be made of it is the Crestoloy wrench. This, it is stated, is one-third thinner than the old style Crescent wrench but is able to withstand a strain twice as great as that required to break the old wrench. These wrenches are made in 6, 8 and 10-in. sizes.

News Notes

ANNUAL CONVENTION of the National District Heating Association is to be held at Hotel Statler, Boston, Mass., June 2 to 5, 1931. Davis S. Boyden, 39 Boylston St., Boston, Mass, is chairman of the General Committee, and D. L. Gaskill, of Greenville, Ohio, is secretary-treasurer of the N.D.H.A. Further details of the convention may be obtained from them.

BUSH TERMINAL Co. has ordered seven 55-ton oil-electric locomotives from Ingersoll-Rand Co. They will be used in switching service at the company's terminal at the foot of 43rd St., Brooklyn, N. Y. Each of these locomotives is powered by an Ingersoll-Rand 300-hp. railroad type Diesel engine. General Electric Co. will supply all the electrical equipment.

SEMET-SOLVAY Engineering Corp. of New York has acquired patents and manufacturing rights relating to the Koller gas producer and the Koller mechanical grate, together with the industrial gas equipment formerly manufactured and sold by the Gas Research Co. and the Smith Gas Engineering Co. of Dayton, Ohio. Both of these lines will be further developed and marketed with the present Semet-Solvay Engineering gas and coke plant and welded equipment.

R. E. J. SUMMERS resigned on March 31, 1931, as vice president and contract manager of the H. K. Ferguson Co., Inc., to become president of Summers Engineers & Constructors, Inc. This organization, which will continue to specialize in industrial engineering and construction, has offices in Graybar Bldg., New York City, and Terminal Tower Bldg., Cleveland, Ohio.

STEPHENS-ADAMSON MFG. CO., of Aurora, Ill., has enlarged its Chicago office and moved to new quarters at 20 North Wacker Drive, where C. H. Adamson, secretary of the firm, will be in direct charge of sales and engineering for the Chicago territory. Confidence in the growing importance of Chicago as a manufacturing center is given as the reason for the increased sales and engineering staff. C. H. Adamson has been director of all Stephens-Adamson advertising and sales promotional work for many years, is a graduate of Carnegie Institute of Technology and an engineer of experience and ability.

FRANK R. PHILLIPS, who has been connected for 21 yr. with public utilities in Pittsburgh in engineering and executive capacities, has been elected president of the Philadelphia Co. to succeed John J. O'Brien who is now president of Standard Gas and Electric Co.

ERIE CITY IRON WORKS, Erie, Pa., has appointed Thomas O. Schrader, Jr. district sales agent with office at 716 Investment Bldg., Pittsburgh, Pa. A. H. Kennedy has been appointed district sales agent with office at 316 Glencoe Bldg., Duluth, Minn. The San Francisco territory has been extended with the appointment of C. W. Kennecott as sub-agent with office at 800 Santa Fe St., Los Angeles, Cal.

PUBLIC SERVICE ELECTRIC and Gas Co., at Newark, N. J., has recently awarded the Westinghouse Electric & Manufacturing Co. an order for a 75,000 kw., 60 cycle, single-cylinder steam turbine-generator unit to be installed as their No. 6 steam unit at the Kearny Generating Station and which will bring the capacity in steam units in this station up to approximately 290,000 kw. This new 75,000-kw. Westinghouse turbine unit will receive part of its steam from the mercury vapor condensers serving the 20,000 kw. mercury-vapor unit recently ordered from the General Electric Co. The major portion of the steam required to operate to full capacity the new 75,000 kw. Westinghouse turbine will come from the existing boiler equipment installed at the Kearny Station.

In addition to the foregoing, the Public Service Electric and Gas Co. has also recently ordered from the Westinghouse Electric and Manufacturing Co. an 18,000-kw., high-pressure, 60-cycle turbine unit for its Burlington Generating Station, to operate in connection with new boiler equipment on 650 lb. steam pressure—850 deg. total temperature, and to exhaust into a low pressure steam header serving three existing Westinghouse 200 lb. steam turbine units. By the addition of this new high-pressure turbine being effected with the station auxiliaries, the Burlington station is being remade into a most economical generating station and will be capable of developing approximately 55,000 kw. The approximate value of the two steam turbine units placed with the Westinghouse Electric and Manufacturing Co. is $1,250,000.

AT ITS RECENT SESSION the Iowa legislature adopted a measure empowering the Iowa state board of assessment and review to list and assess any property in the state, including that of individuals, full partnerships, corporations, or associations operating for profit, waterworks, electric light or power, railways and other public utilities, including pipe lines and requiring annual reports before Jan. 15 which, with any other information desired, may be used to determine valuations. Review of any assessment may be had before the board within 10 days after the assessment is certified to the county auditor and appeals may be taken to the district court. Surplus funds of municipally-owned public utilities may be transferred for use in municipal improvements under another measure. Assessment of pipe line companies is placed under the state board of assessment and review and failure to report, by April 1 of each year, on property owned, earnings and operating expenses, subjects the company to 25 per cent increase in valuation after the same is fixed by the board. The railroad commission is authorized to issue permits for pipe line construction with permit fee fixed by diameter of the pipe and annual fee of half that amount collected. Natural and artificial gas pipe lines are placed under supervision and usual regulations of other public utilities.

GEORGE H. CLIFFORD, president of Stone & Webster Service Corp., has transferred his office from Boston to New York, where he will continue to direct the service corporation. C. F. W. Wetterer will also move from Boston to New York and will continue as vice-president of the service corporation.

Donald C. Barnes, who has been division manager for Stone & Webster Service Corp., will have his office in New York and has been made vice-president of Engineers Public Service Co. Davis W. De Bard, formerly sales executive for the corporation in Boston is transferred to the New York office to handle the sales direction of the Engineers Public Service Co.

YEOMANS BROTHERS Co., Chicago, Ill., announces the appointment of the following new representatives: Andriot Davidson Co., 1307 Starks Bldg., 4th and Walnut St., Louisville, Ky.; Johns Equipment Co., 1st National Bank Bldg., Fort Wayne, Ind.; H. A. Grossman Co., 3221 Olive St., St. Louis, Mo.

ROLLER-SMITH CO., 233 Broadway, New York, N. Y., announces the appointment on April 1 of the Commercial Engineering Co., 1800 E. St., N. W., Washington, D. C., as its sales agent in the District of Columbia.

OPELOUSAS ELECTRIC LIGHT & WATER WORKS, Opelousas, La., is increasing the capacity of its plant from 1100 hp. to 2060 hp. by the installation of another 960-hp. Busch-Sulzer Bros. Diesel engine. The present equipment consists of two 250-hp. and one 600-hp. engine, all four-cycle units made by Busch-Sulzer. The new 960-hp. unit is to be a two-cycle engine and the manufacturer will supervise its installation. The new unit will cost about $55,000. The plant also contains three Worthington pumps of about 1200-g.p.m. capacity.

EDGAR J. KATES, consulting engineer, announces the removal of his office to 1350 Broadway, New York City.

PROPOSED CODES for fusion welding of unfired pressure vessels and of drums or shells of power boilers were considered at the meeting of the A.S.M.E. Boiler Code Committee held on April 23. Important changes were made in view of the criticisms and suggestions that had been received, including those from the American Welding Society and the Compressed Gas Manufacturers Association. The proposed codes with the revisions which were agreed upon will be published in the June issue of Mechanical Engineering. It is contemplated that final action will be taken at the June meeting of the Boiler Code Committee and it is important that all discussions be received before June 15. Preprints will be available about May 15, and may be secured by communicating with the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y.

GRINDLE FUEL EQUIPMENT Co., Harvey, Ill., a subsidiary of the Whiting Corp., has purchased the exclusive manufacturing and selling rights to the Bethlehem pulverizer formerly manufactured by the Bethlehem Steel Co.

LINK-BELT Co., Chicago, Ill., announces the appointment of William L. Hartley, who has been in the employ of the company since 1915, as District Sales Manager in charge of the Detroit, Mich. office, to be located at 5938 Linsdale Ave., telephone number Euclid 1000.

AT THE ORGANIZATION meeting of the board of directors of the Westinghouse Electric & Manufacturing Co. held April 29, the following officials were elected. A. W. Robertson, chairman of the board; F. A. Merrick, president; J. S. Tritle, vice-president in charge of manufacturing; S. M. Kintner, vice-president in charge of engineering; W. S. Rugg, vice-president in charge of sales; L. A. Osborne, H. P. Davis, H. D. Shute, J. S. Bennett, H. T. Herr, Walter Cary, T. P. Gaylord, and Harold Smith were re-elected vice-presidents. C. H. Terry was elected an honorary vice-president. E. M. Herr was reëlected vice-chairman.

Books and Catalogs

INTERNAL COMBUSTION ENGINES, by J. A. Polson; 475 pages, illustrated; cloth 6 by 9 in.; John Wiley & Sons, Inc., New York; price, $5.00.

Although prepared by the author, who is professor of Steam Engineering, University of Illinois, for use by junior and senior engineers in engineering colleges and universities who have studied thermodynamics, this book will also be of interest to designers and operators of internal combustion machinery. To avoid confusion the Otto cycle is first discussed, then the Diesel cycle. In both cases the author has first described and illustrated the cycle before discussing the theoretical development. The latter is treated by the Air standard constant specific heat method and by the variable specific heat method. Following the theoretical discussion, performance and test data are presented and analyzed.

After discussing the general principles of the cycles, various chapters consider blast furnace gas engines, illuminating gas engines, the automobile engine, gasoline, carburetors, automobile engine performance, the airplane engine, ignition system for automobile and airplane engine, the Diesel cycle and its thermodynamics, Diesel engine performance, fuel oil and fuel injection, cooling, valves and testing of internal combustion engine.

AMERICAN DIESEL ENGINES, by L. H. Morrison; 600 pages, 387 illustrations; cloth, 6 by 9 in.; McGraw-Hill Book Co., 370 Seventh Ave., New York City; price, $5.00.

This new book, as its title indicates, deals only with American Diesel practice in order to confine the material within the limits of a single volume. The early history of Diesel development, as well as some phases of the economics of oil engine power plants, are treated in the earlier chapters. Then follow chapters on modern air injection Diesels, the air and solid injection Diesel, oil engine installation, Diesel engine frames, main bearing and crank shaft, pistons, connecting rod, cylinders, cylinder head, valves, fuel valves and pumps. Lubrication is discussed at some length, as well as Diesel engine fuel system, fuel oils, air compression system, engine output and operating procedure. The book is well illustrated with halftones and many drawings showing details of engine parts. For anyone operating or concerned in any way with Diesel engine installations, this book should prove a most valuable source of information.

MECHANICAL WORLD ELECTRICAL POCKET BOOK, 1931; 396 pages, cloth, 3 by 6 in.; Emmott & Co., Ltd., 65 King St., Manchester, England; price, 35 cents.

The latest edition of this book carries on the traditions established by previous issues for completeness of treatment, compact arrangement, up-to-date information and convenience for electrical engineers in every line of industrial and central station work. In view of the increasing and expanding undertakings served in England by the Grid system of electrical transmission, some of the new contributions this issue relate to the operation and maintenance of heavy electrical engineering equipment, such as found in power plant and electric traction work. Former sections have been retained, those on lighting circuits and switching have been entirely revised and those concerning lamps and lighting have been expanded and brought up to date. A copious supply of tables contains data derived from many recent installations. Much of the matter in the early sections has been brought up to date to cover latest developments in direct current equipment, synchronous motors, auto synchronous and synchronous induction motors. Although these Mechanical World Pocket Books relate specifically to English practice, American engineers will find much valuable material in them.

POWER STATION CHEMISTRY, recently issued as publication No. 14 by the Prime Movers Committee, Engineering National Section, National Electric Light Assn., described methods for the sampling and testing of bulk and powdered coal, laboratory methods for the sampling and testing of power plant steam and water supplies and notes stressing the necessity for the proper sampling of water and steam in the boiler systems. This may be obtained from the N.E.L.A. headquarters, 420 Lexington Ave., New York City.

ELECTRIC SERVICE for Hotels and Office Buildings, is the title of publication No. 112, a report of the General Power Committee, Commercial National Section, National Electric Light Association, 420 Lexington Ave., New York City.

The purpose of this report is to compile information and data on the use of electric service in hotels and office buildings, which will serve as a guide for engineers, architects and the owners of such buildings or buildings of a similar character, in selecting a source of electric service.

The report generalizes on the application of purchased electric service. It brings out the tangible and intangible advantages of such service; indicates methods used in the territory of one operating company to obtain fundamental data necessary for the study of such applications and gives actual operating data on a number of buildings which can be used as a basis for comparison in setting up similar data for a proposed building.

TESTS OF A MIKADO-TYPE LOCOMOTIVE, NICHOLSON THERMIC SYPHONS, by Edward C. Schmidt, Everett G. Young, and Herman J. Schrader. Issued by the Engineering Experiment Station of the University of Illinois, Urbana, Ill., as Bulletin 220; 6 by 9 in., paper, 99 pages; price, $0.55.

One of the recent innovations in steam locomotive design, is the thermic syphon, a supplementary water-leg or circulating chamber applied in the firebox of the locomotive. Its purpose is to stimulate the circulation of the boiler water and to increase the transfer of heat from the fire to the steam. The bulletin gives the results of 24 tests of a Mikado-type freight locomotive which was operated first without the syphons and again after they were installed. Tests were made at four rates of evaporation covering the ordinary range of operation in daily service and at speeds of from 14 to 32 mi. per hr. The cutoff varied from 25 to 45 per cent. Twenty thousand pounds of coal were burned in each test. The report shows that at the four rates of evaporation the increase in boiler efficiency effected by the syphon was 11.6, 8.4, 7.3, and 6.6 per cent, respectively, the general average increase for all four rates being 8.5 per cent; that is, under identical conditions of operation the weight of steam generated per pound of coal would be on the average 8.5 per cent greater with the syphons than without them.

REPORT of the boiler test made by the Commercial Testing and Engineering Co. at Booth 440 at the Fifth Annual Mid-West Power Show in Chicago, in February, as recently described in Power Plant Engineering, is being issued in bulletin form by Whiting Corp. of Harvey, Ill.

BULLETIN 223, entitled "Investigation of Various Factors Affecting the Heating of Rooms with Direct Steam Radiators," prepared by Arthur C. Willard, Alonzo P. Kratz, Maurice K. Fahnestock and Seichi Konzo, has recently been issued by the Engineering Experiment Station of the University of Illinois. The bulletin reports the continued investigations of this subject which have been reported in previous bulletins of the University. In this report the effect of various factors encountered in actual heating practice on the heating of a typical room by means of cast-iron radiators is studied. Among these factors were the location of the radiators; type of radiators, enclosures, shields, and covers; kind of paint used on radiators; storm doors and sash; variation in attic and basement temperatures; relative amount and location of wall and glass exposure; and variation in steam temperatures. A specially constructed low temperature testing plant was used in making these investigations. Copies of this bulletin may be obtained without charge by addressing the Engineering Experiment Station of the University of Illinois.

DIESEL POWER PLANT HANDBOOK, by Julius Kuttner; 280 pages, illustrated; leather, 8 by 11 in.; published by Diesel Power, New York City; price, $5.00.

This is the sixth edition of this handbook, formerly the Oil Engine Power Handbook. It consists of two parts, the first entitled Engine Room Guide, the second, a catalog section containing illustrations of practically all the engines made by American manufacturers, accompanied by detailed data on their construction, capacities and important features.

The various chapters of the text under the title Engine Room Guide, discuss first the position of the Diesel engine in American industry, then properties of the Diesel engine, airless injection of fuel sprays, fuel injection pump, air injection fuel sprays and air injection compressor. Other chapters are devoted to 4-cycle engine valves, 2-cycle engine details, major bearings, piston, cooling and maintenance, piston ring action and piping. Exhaust heat recovery receives considerable attention and the importance of air filtration is emphasized. The last two sections of the text discuss the important subject of lubrication, giving data on lubricants and their proper use.

TABLES of chemical composition, physical and mechanical properties and corrosion resistant properties or corrosion resistant and heat resisting alloys. Published by the American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa.; price, $1.50.

Tables and data of corrosion resistant and heat resisting alloys assembled by Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and related alloys. Data are assembled in the form of 11 large tables split into 6 parts, grouped according to manufacturers, the manufacturers in general being listed alphabetically. Fabrication, chemical composition, physical and mechanical properties and corrosion resisting properties are tabulated.

NATIONAL Research Council Bulletin by Clarence J. West and Callie Hull. Published by the National Research Council, National Academy of Sciences, Washington, D. C., Fourth Edition. 267 pages, 6½ by 10 in., paper; price, $2.00.

A comprehensive list of the industrial and consulting research laboratories of the United States. The bulletin is in four parts; the first is a list of laboratories arranged alphabetically according to the name of the company. This list gives the address, name of the research staff and the research work being carried on. The second list is arranged alphabetically under the name of the director, giving the company connection and address. The third list is a geographical one by States and the last list is by subject classification or index. More than 1600 laboratories are listed in this edition and laboratories connected with Federal, State or Municicipal Government or with Educational Institutions have been excluded but 186 of the latter laboratories are listed in Miscellaneous Publication No. 90 of the Bureau of Standards.

ROCK TUNNEL METHODS, a 77-p. booklet published by the Hercules Powder Co., Wilmington, Del., describes the drilling, blasting, excavating, transportation, ventilation and lining of 31 tunnels in all parts of the world. These 31 tunnels are grouped in the following order: Tunnels used for railroad transportation; mine tunnels constructed mainly for drainage or ore haulage purposes; water tunnels for city water supply and tunnels driven primarily for hydroelectric projects.

ECONOMY GREASE is the subject of a 20-page bulletin recently issued by the Economy Lubricating Co., Charlestown, Mass. The booklet discusses how Economy Grease is different, engineering service with specific instances of the company's help on lubrication, a few pointers on grease lubrication, consistencies of grease and special lubricating problems such as ball and roller bearings, chain drives and grease guns. The bulletin also contains data on True Blue boiler treatment.

SMOLENSKY noiseless flanged check valves, their construction, application and operation are discussed in bulletin No. 3 issued by The Smolensky Valve Co., Cleveland, Ohio. The company has also issued bulletin No. 9 discussing the Smolensky radialflow noiseless check valves especially designed to eliminate head loss and to be used for municipal waterworks, oil refineries and similar applications. Straightflow Lock Valves for pressures from 125 to 1350 lb. in sizes from one inch up, screwed and flanged are described in bulletin No. 8.

ATMOSPHERIC POLLUTION from Fly-Ash is the name of a new publication by the Strong-Scott Mfg. Co., Minneapolis, Minn., that offers a few facts regarding a popular fallacy that pulverized fuel-fired boiler plants are becoming public nuisances.

DURABLA specialties are described in an attractive leather-bound 80-page book, known as catalog No. 12, by Durabla Manufacturing Co., 114 Liberty St., New York City. This discusses compressed asbestos fibre sheet packing, gaskets in general, tests for low and high pressure operation and gives tables of sizes and prices of all types of Durabla gaskets. Rod packing, gage glasses and washers, valve discs and pump valves are also described in detail with complete tables of sizes and prices for each item.

PULVERIZED FUEL is the subject of report No. 12 recently issued by the Prime Movers Committee, Engineering National Section, N.E.L.A., 420 Lexington Ave., New York City. This report includes statements for 1929 on pulverized fuel from 29 operating companies, covering: Equipment, Mills and Exhausters, Coal Fineness, Sampling Methods, Combustible in Fly Ash, Dryers, Vent and Washing Methods, Boiler Operation, Boiler Outages and Maintenance Methods, Burner and Furnace Performance, Control. Statements are included from 13 manufacturers.

COMBUSTION TESTS with Illinois Coals, is the title of a report just issued as bulletin No. 213 by the University of Illinois, Engineering Experiment Station, Urbana, Illinois. These tests are conducted in coöperation with The Zeigler Coal and Coke Co. by Alonzo P. Kratz and Wilbur J. Woodruff and discuss first the methods and procedure of the tests, curves and diagrams showing the relation between various factors and many tables showing the test results, together with a summary of the conclusion to be drawn. The Engineering Experiment Station is also issuing bulletin No. 214 on The Effect of Furnace Gases on the Quality of Enamels for Sheet Steel.

VICTOR-ACME BLOWERS are described in two new bulletins, 21-B10 and 21-B11 by the Roots-Connersville-Wilbraham division of the Stacey Engineering Co., Connversville, Ind. In combining the Victor and Acme lines a wider range of capacity than formerly possible is now offered. Two new types, the "AF" with anti-friction bearing and "AFS" with anti-friction bearing and hardened steel gear have also been added and are explained in the bulletins. Price list and detailed description of the units are given.

ATLAS EQUIPMENT for central stations is described in a recent bulletin issued by The Atlas Car & Mfg. Co., Cleveland, Ohio. Detailed description is given of storage battery locomotives, transformer transfer cars, transformer cars, rotor cars, gable bottom coal cars, weigh larry, turntables, industrial cars, buckets, and various types of platform trucks.

INSTRUMENTS, RELAYS, and electronic devices are described and illustrated in a 136-page publication, identified as Catalog 211, recently announced by the Westinghouse Electric and Manufacturing Co., Newark, N. J. Of special interest in this booklet are the electronic devices, including photo-electric tubes, grid-glow tubes, light relays and other devices, for which the applications in modern industry are ever-increasing in number. Other equipment covered by the new catalog includes: ammeters, voltmeters, frequency instruments, galvanometers, oscillographs, potentiometers, power factor meters, tachometers, recording and indicating wattmeters, protective relays, and large number of other instruments and relays. Each instrument is described with respect to application and construction, and the sizes, style numbers and prices are included.

HEATING IN SWITCHES AND PANELBOARDS is discussed by J. G. Jackson, Director of Engineering, Square D Co., in a report of the Square D Co., Detroit, Mich., which is being issued by the company in the form of a 4-page bulletin. Analysis of the heating effect in this equipment is made, with tables and comparisons of heat losses in various types of fuses and switches.

DESIGNING AND BUILDING GAS LINES with Smith-welded pipe is discussed in bulletin No. 510 by A. O. Smith Corp., Milwaukee, Wis. The bulletin takes up first the factors that affect minimum cost of gas pipe lines, then a detailed discussion of pipe line welding with photographs showing the installations of pipe and concludes with a presentation of engineering data on welded pipe.

REVOLVING CAR DUMPERS, their construction, operation and views of typical installations are discussed in a recent bulletin No. 93 by The Wellman Engineering Co., Cleveland, Ohio.

BENSON BOILER INSTALLATION at the heating and power plant of the cable works of the Siemens-Schuckertwerke at Berlin-Siemensstadt, Germany, is described in detail in a recent bulletin of the company that is being distributed by Carl. A. Mayr, 75 West St., New York, N. Y.

LARGE DIESELS FOR PUBLIC UTILITIES are described and illustrated in a recent 50-page bulletin published by Busch-Sulzer Bros. Diesel Engine Co., St. Louis, Mo. The work of Dr. Rudolph Diesel and Adolphus Busch is discussed. Detailed data are given on new motorship of over 10,000 t. requiring in some cases as much as 15,000 to 20,000 Diesel hp. Comparison of Diesel engine stations with steam plants as to design and arrangements is emphasized and details of the Busch-Sulzer Diesel engines are given to illustrate the simplicity of design. Many photographs are included of Diesel installations, both marine and stationary in large and small sizes.

COPPUS STEAM TURBINES up to 60 hp., also fractional hp., are described in bulletin No. 135-5, distributed by the Coppus Engineering Corp., Worcester, Mass. Complete details of constructions of housing, bearing, shafts, turbine wheels and other parts are given with tables and sketches of dimensions and a set of performance curves showing relation between horsepower steam pressure and water rate. The bulletin contains a discussion of how these performance curves should be used and interpreted to determine the right size of steam turbine for a given condition and the water rate which may be expected.

IN GENERAL BULLETIN No. 102, single-stage, double-acting horizontal air compressors are described by the Pennsylvania Pump & Compressor Co., Easton, Pa.

WATTS RELIEF VALVES are described in detail and well illustrated in an 8-page folder issued by Watts Regulator Co., Lawrence, Mass. Diaphragm relief valves for pressure relief only, also valves for temperature, pressure and vacuum relief and a type for temperature and pressure relief, in addition to the autotherm relief valve, are illustrated in detail.

FOLLOWING new publications have just been issued by General Electric Co., Schenectady, N. Y.: Vertical Waterwheel-driven Generators, Publication GEA-820A; Rectangular Switchboard Instruments, GEA-1135A; Outdoor Switch Houses, Manual and Automatic types—2300 to 15,000 v. 5 to 1600 amp.—GEA-782C; Totally Enclosed, Fan-cooled Induction Motors, ¾ to 30 hp.—GEA-1341; G-E Automatic Tank and Pipe Welder, GEA-1351; Station Oil Circuit Breakers, 15,000 to 23,000 v.—600 to 4000 amp., GEA-703A; Small Synchronous Condensers, GEA-1337; Manually Operated Field Switches, GEA-831A; Steel-Panel Switchboards, GEA-1128A; G-E Electric Brazing Equipment for brazing or hard soldering brass, copper, bronze or steel—GEA-1311A; The G-E Thermostat for use on either A.C. or D.C. circuits, GEA-311A; Miniature Instruments for Panel Mounting, GEA-1239; Type PQ Relays, GEA-970B.

Power Plant Construction News

Calif., Los Angeles—The International Sugar Co., 637 Battery Street, San Francisco, plans installation of electric power equipment, and power house at proposed new sugar refinery in vicinity of Los Angeles, where site is being secured. Entire project is reported to cost close to $100,000.

Calif., Watsonville—The Union Ice Co., 354 Pine Street, San Francisco, has approved plans for a one-story ice-manufacturing plant at Watsonville, 75 x 100 ft., reported to cost $100,000, with equipment. Engineering department is in charge.

Ga., Cordele—The Sawyer Coal & Ice Co., 277 Walnut Street, Macon, Ga., is said to have plans nearing completion for a proposed new ice-manufacturing plant at Cordele, to cost about $70,000, with equipment. C. T. Baker, Walton Building, Atlanta, is engineer.

Ga., Fort Valley—The Common Council has plans under way for extensions in municipal waterworks, including filtration plant unit, tanks, etc., Warren E. Darrow, Masonic Temple, Columbus, Ga., is consulting engineer.

Ill., Arlington Heights—The Village Council is said to be arranging a bond issue of $50,000, for extensions and improvements in municipal water system, including deep-well, motor-driven pumping machinery and auxiliary equipment. H. G. Peter is village clerk.

Ill., Lemont—The Consumers Co., Lemont, is said to be planning installation of electric power equipment in connection with proposed rebuilding of portion of stone crushing plant, including machine shop and other mechanical units, entire loss reported at $200,000.

Ind., Lebanon—The Pure Serum Co., Thorntown, Lebanon, is said to be planning the installation of electric power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire with loss reported over $75,000.

Md., Centerville—The Common Council has secured permission from the State Legislature to arrange for a bond issue of $70,000, proceeds to be used for extensions and improvements in municipal electric light and power plant.

Md., Elkton—The Elk Mills Fabric Co., Elk Mills, near Elkton, is considering the installation of a hydroelectric generating plant on the Big Elk River, for service at the mill. Estimates of cost will soon be made. William R. Baldwin is president.

Mass., Holyoke—The Holyoke Water Power Co., Holyoke, has plans maturing for a proposed hydroelectric power plant on local site, reported to cost over $350,000, with equipment. R. A. Smith, 1 Canal Street, Holyoke, is engineer.

Mass., Northbridge—The Kupfer Brothers Co., Northbridge, is said to be planning installation of electric power equipment in proposed new addition to coated paper products plant in the Riverdale section, entire project reported to cost more than $60,000.

Mich., Jackson—The Consumers Power Co., Jackson, has plans under way for a control house, equipment storage and distributing plant at the Croton Dam, Muskegon River, to cost about $35,000. Company engineering department is in charge.

Mo., Cape Girardeau—The Missouri Utilities Co., Cape Girardeau, is said to be planning the installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in water plant at Cape Rock, entire project reported over $150,000.

Mo., Kansas City—The Wabash Elevator Co., Railway Exchange Building, St. Louis, affiliated with the Wabash Railroad Co., plans installation of electric power equipment in proposed addition to grain elevator at North Kansas City, entire project reported to cost over $250,000. M. F. Longwill, Railway Exchange Building, is engineer.

Mont., Bozeman—The Ohio Oil Co., Findlay, Ohio, is said to be planning early construction of a pipe line for natural gas service from Dry Creek oilfield, in Southern part of Montana, to Bozeman and vicinity, about 125 miles, including compressor stations, booster equipment and other mechanical equipment, entire project to cost over $2,000,000. Company engineering department will be in charge.

Neb., Lincoln—The Board of Trustees, University of Nebraska, Lincoln, has completed plans for a one-story and basement steam power house, for central heating service, reported to cost over $40,000, with equipment. L. F. Seaton, Administration Building, is superintendent, in charge.

N. H., Portsmouth—The Board of Public Works, Charles A. Allen, superintendent, plans installation of electric motors, electric oil heater, pumping equipment and other mechanical apparatus, in a proposed new municipal asphalt plant, for which plans are being completed.

N. Y., Buffalo—The Buffalo Electric Furnace Co., River Road, Tonawanda, plans installation of electric power equipment in connection with an expansion and improvement program at plant, reported to cost over $80,000. Company has recently arranged for an increase in capital from $280,000 to $400,000.

N. Y., Corinth—The International Paper Co., 220 East Forty-second Street, New York, is said to be planning installation of power equipment in connection with proposed rebuilding of newsprint mill at Corinth, recently destroyed by fire with loss reported over $100,000.

N. Y., New York—The Yorkville Sash & Door Co., Garrison Avenue and Whittier Street, Bronx, is said to be planning installation of motors and other power equipment, in connection with proposed rebuilding of woodworking plant, recently destroyed by fire with loss reported in excess of $100,000.

Ohio, Cleveland—The Gulf Refining Co., Frick Annex, Pittsburgh, Pa., is planning installation of pumping machinery and other mechanical equipment in connection with extensions and improvements in oil storage and distributing plant on Jefferson Avenue, Cleveland, entire project to cost about $175,000. Company engineering department is in charge.

Ore., Medford—The California Oregon Power Co., Medford, has made application for permission to construct a power dam near the mouth of Brush Creek, Siskiyou County, Calif., for a proposed hydroelectric power development. The power dam will be about 160 ft. high, and station will be equipped for an initial output of about 14,000 kw. Company engineering department is in charge.

Okla., Tulsa—The Carbonic Products Co., Tulsa, plans installation of electric power equipment in connection with proposed new dry ice-manufacturing plant on site recently acquired on North Lewis Avenue, to be equipped for a capacity of six tons a day, entire project reported to cost over $50,000.

Pa., Denbeau—The Gulf Refining Co., Frick Annex, Pittsburgh, Pa., plans installation of pumping machinery and other power equipment in proposed new oil storage and distributing plant at Denbeau, entire project to cost over $100,000. Company engineering department is in charge.

Pa., Philadelphia—The Philadelphia Gas Works Co., 1401 Arch Street, Philadelphia, has plans for a gas testing station at Seventeenth Street and Passyunk Avenue, reported to cost over $45,000, with equipment.

Pa., Pottstown—The Board of Directors, Hill School, Pottstown, has had plans completed for a new power house at the institution for central heating service. Estimated cost has not been announced. The Ballinger Co., Twelfth and Chestnut Streets, Philadelphia, Pa., is architect and engineer.

Pa., Scranton—The Princeton Rayons, Inc., 150 Madison Avenue, New York, plans installation of electric power equipment in proposed new rayon mill at Scranton, entire project to cost over $250,000. It is understood that a boiler house will be built.

Utah, Logan—The City Council has plans maturing for extensions and improvements in municipal electric light and power plant, including installation of a 600-kw. Diesel engine unit and auxiliary equipment, reported to cost about $65,000.

Utah, Salt Lake City—The Utah Power & Light Co., Salt Lake City, has secured permission for the construction and operation of a steam-operated electric generating plant on Utah Lake, and plans to begin work at early date. Plant is reported to cost over $250,000.

Va., Winchester—The H. J. Heinz Co., 1062 Progress Street, Northside, Pittsburgh, Pa., plans installation of electric power equipment in proposed addition to canning plant at Winchester, entire project reported to cost over $85,000.